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Obesity related lifetime medical costs and risk-adjusted contributions: the effect of risk equalization on prevention incentives from the insurer's perspective

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ABSTRACT

For the last years, concerns have been expressed about the rapid rising health care expenditures and epidemiological transition to chronic diseases, which pressures the health sector and labor force. Prevention of chronic diseases plays a central role in this debate and is desirable in both reducing health care expenditure and increasing quality of life and society. Hence, providing optimal incentives for insurers to invest in prevention and promote healthy life styles is socially desirable. The Dutch risk equalization model provides insurers risk-adjusted contributions to discourage risk selecting, which is also socially desirable. However, as improvement of the model further discourages risk selecting, it also might discourage prevention efforts by insurers as differences in the health of insureds becomes financially less relevant. Improvement of the risk equalization model, therefore, might induce a societal trade-off between discouraging risk selecting and encouraging health improving behavior by insurers. This trade-off is also referred to as the 'prevention paradox'. This research aims to quantify this prevention paradox applied on obesity-related diseases.

Health care costs and revenues for obese and healthy living individuals are compared to analyze the relative financial attractiveness of both groups for insurers. Revenues consist of risk-adjusted contributions from the risk equalization fund. These risk-adjusted contributions influence insureds financial attractiveness and corresponding incentives. The RIVM Chronic Disease Model is used to simulate a healthy living and obese cohort consisting of 500 men and 500 women. Their life course and obese related disease prevalence's are used to determine lifetime health care costs and risk-adjusted contributions under the 2018 Risk Equalization model. Insurers' net revenue is determined by subtracting health care expenditure from risk-adjusted contributions. Healthy living individuals are financially most attractive for the insurer compared to obese individuals. This difference did decrease compared to the 2012 Risk Equalization model used in Kanters et al. (2013). Increased prediction of the model decreases the financial incentive for insurers to engage in health promoting activities, but also the incentive to engage in risk selection. The net revenue differences between healthy living and obese individuals over their lifetime (€4500) and per year (€70) are quite modest, indicating that the financial incentives for insurers are quite limited and cheap risk selection might be more favorable for insurers. The more effective the prevention treatment, expressed in reductions of obese related diseases, the more profitable and financially attractive an obese individual became. However, under favorable circumstances (50% reduction in obese related diseases) it still takes an insurer more than 20 years to earn back the initial prevention investment. Hence, risk selection might therefore be more effective and cheaper as effects are noticeable in the short term and can be targeted at low or high risk individuals at the group level. This stresses the need for the incorporation of additional prevention incentives and reducing existing selection incentives in the risk equalization model.

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LIST OF ABBREVIATIONS

Chronic Disease Model	CDM
Cost of Illness	COI
Durable medical equipment costs groups	DMCG
Dutch National Health Care Institute	ZiNL
Health Care Insurance act	ZVW
International Classification of Diseases, Tenth Revision	ICD-10
International Classification of Primary Care	ICPC
Ministry of Health, Welfare and Sport	VWS
Multiple-year high costs	MHC
National Institute for Public Health and the Environment	RIVM
Life expectancy	LE
Long-term Care Act	WLZ
People per address	PPA
Physiotherapeutic costs group	PHCG
Pharmacy costs groups	PCG
Primary diagnostic costs groups	pDCG
Risk Equalization Fund	REF
Secondary diagnostic costs groups	sDCG
Socio-economic status	SES
Source of income	SoI

Chapter 1. Introduction

Under the Dutch Health Care Insurance act (ZVW), health insurers are obliged to act as careful purchasers of care. They play an important role in containing health care costs and safeguarding quality of care (Nederlandse Zorgautoriteit & Zorginstituut Nederland, 2020; Zorgwijzer, 2020). In a perfect competitive health insurance market, insurers would charge risk-adjusted premiums for health plans according to the health risk of the consumer (risk selecting) and provide risk-adjusted benefit packages designed to attract specific risk types (cream skimming). Risk-adjusted premiums and benefit packages are not desirable under the solidarity principle. They negatively affect access to care, quality of care and efficiency (Van de ven & Ellis, 2000). The Dutch health insurance system is built on the principles of regulated competition and solidarity. Hence, the Dutch health insurance system is characterized by open enrollment, community rated premiums and a universal basic insurance package (Van De Ven & Schut, 2008). In order to correct for risk selecting incentives induced by these restrictions, risk equalization is used. Health insurers receive a risk-adjusted contribution from the Risk Equalization Fund (REF) to compensate for predictable risk variation. In other words, insurers receive (or pay) financial compensation for insureds with increased risk for high (or low) health care costs. Predictable risk variation that is not fully compensated for is also referred to as unpriced risk heterogeneity. The risk-adjusted contribution is based on the average risk profile of the insurer's consumer population (Eijkenaar & van Vliet, 2017; Van Kleef et al., 2013).

The main purpose of the Dutch Risk Equalization Model is to mitigate incentives for risk selecting, create a fair playing field and stimulate careful purchasing of health care (Schut & Van De Ven, 2011) In the last decades, the Dutch Risk Equalization Model has been improved to a sophisticated morbidity-based model, but is still far from perfect (Eijkenaar & van Vliet, 2017; Schut & Van De Ven, 2011; Van De Ven et al., 2004). A perfect risk-adjustment model would rule out risk selecting and cream skimming incentives to enhance solidarity as differences in health status are fully compensated for. Simultaneously, this could reduce incentives for preventive action by insurers (Kanters et al., 2013; Van de ven & Ellis, 2000). Under perfect risk equalization, insurers investing in good quality of care, innovation or prevention to improve its consumer's health status, take advantage of lower future health expenditures, but also equally lower risk equalization contributions. Net revenue for each insurer will be zero regardless of the risk they run on their pool of insureds. Hence, insurers feel no financial incentive to engage in health improving activities under perfect risk equalization. Imperfect risk equalization, on the other hand, could create financial incentives to engage in prevention as insurers are able to exploit existing unpriced risk heterogeneity. Low-risk individuals will be more profitable for insurers than unhealthy or elderly due to overcompensation under the risk equalization model (Eijkenaar et al., 2018; Van Kleef et al., 2013). This incentivizes insurers to actively select insureds based on their risk profile, but it also might stimulate insurers to promote healthier lifestyles and invest in prevention or innovation.

As opposed to risk selection, prevention and innovation are beneficial and desirable for society. It reduces waste of health care resources and repression of care. Prevention also plays a central role in the current healthcare movement, where the aim is to shift the focus of the entire healthcare sector from sickness and care to health and behavior. This with the rationale that preventing diseases is better than curing diseases, health care close(r) to home is more comfortable and lifestyle interventions are more sustainable and produce higher quality of life than treatment of diseases. The public debate about prevention of chronic diseases is and continues to be increasingly important due to aging population, capital constraints and labor shortage (Nederlandse Zorgautoriteit & Zorginstituut Nederland, 2020; Raad voor de Volksgezondheid en Zorg, 2010). Hence, financial incentives for innovation and prevention borne of imperfect risk equalization are socially desirable, just as the discouragement of risk selecting incentives under perfect risk equalization. Improvement of the risk equalization model, therefore, might induce a societal trade-off between discouraging risk selecting and encouraging health improving behavior by insurers. This trade-off is also referred to as the 'prevention paradox' (Kanters et al., 2013).

This trade-off is not straight forward and explicit. It varies in size depending on external factors. Financial incentives for prevention induced by risk equalization rely for example on the effectiveness of the prevention method and the capability of actually reducing health care costs due to improved health. Insureds' health could be improved through reduced drug intake, for instance. This could mean lower risk equalization contributions for the insurer due to the change in pharmaceutical declarations. If health care costs do not decrease equally due to substitution of costs (extra costs related to the reduced drug intake), prevention will not be profitable and insurers rather face risk selecting incentives. Hence, the relation between imperfect risk equalization and incentives for prevention also depend on the interrelation between effectiveness of prevention and related costs. Additionally, higher lifetime health care costs due to prolonged life caused by prevention of unhealthy life styles might offset financial prevention efforts (in 't Panhuis - Plasmans et al., 2012; Van Baal et al., 2008).

A health-improving activity might be preventing obesity. Obesity is a growing health problem in the Netherlands and linked to a variety of non-communicable diseases, such as type-2 diabetes. (Volksgezondheidenzorg.info, 2021; WHO, 2020). Obesity is largely preventable and initiatives to prevent (deterioration of) obesity will result in health gains and lower obese-related health costs (van Baal et al., 2006; Van Baal et al., 2008). Preventing obesity will yield societal and financial benefits. Although, (by law) the role of the insurer is to act as a prudent purchaser of care, the current (and future) risk equalization scheme might not sufficiently support that role in terms of providing optimal financial incentives for prevention (Nederlandse Zorgautoriteit & Zorginstituut Nederland, 2020). This research contributes by providing new, more recent insights to this debate.

1.1 Objective and research question

The aim of this research is to identify to what extent the Dutch risk-equalization model interferes with insurers' incentives to invest in health-improving activities. More specifically, to what extent does a preventive investment pay-off for an insurer in terms of risk-adjusted contributions and health care costs. This thesis will focus on differences in life-time health care costs and risk equalization contributions between healthy living individuals and obese individuals (BMI>=30). The performances of risk equalization models are usually analyzed yearly. Using a life-time horizon will show an uncommon, but nevertheless useful, insight in the performance of the risk equalization scheme and insurer's incentives.

Furthermore, hypothetical bariatric surgery effects as prevention initiative will be studied in relation to insurer's net revenue (risk-adjusted contribution minus health care costs). Different preventive actions exist that cause significant long-term loss of weight, recovery from diabetes, improvement in cardiovascular risk factors, and mortality reduction. Bariatric surgery appears to be the most cost-effective intervention for moderately to severely obese compared to life-style interventions (Galani & Schneider, 2007; Suijkerbuijk et al., 2012). This research aims to find an answer to the following question:

To what extent does prevention of obesity pay-off for an insurer in terms of life-time risk-equalization payments and health care costs?

And the following sub-questions from the insurer's perspective:

- *To what extent do financial incentives exist between a healthy and obese cohort?*
- *To what extent does prolonged life reduce financial incentives for prevention?*
- *What effect have different levels of prevention effectiveness on insurer's net revenue and the incentive to invest in prevention?*

With empirical answers to the previous questions, we can discuss the following sub-questions:

- *How do risk-adjusted contributions intervene with the role of health insurers as careful purchasers of care*
- *How can prevention and other health-improving initiatives by insurers be financed differently to keep prevention incentives in place?*

This paper is structured as follows. Chapter 2 describes the Dutch health insurance system with its corresponding financial flows. It briefly discusses the 2018 Risk Equalization Model and introduces the prevention paradox. Lastly, it contains a brief description about preventative obesity methods. Chapter 3 describes the data and methods used in this paper. It contains a description of the RIVM-CDM model and the classification of insureds based on modeled disease prevalence rates. Chapter 4 contains the main results. In chapter 5, the findings of this research are summarized in the conclusion and discussed. Additionally, suggestions for further research will be made, which concludes this paper.

Chapter 2. Theoretical framework

2.1 The Dutch health insurance system

The 2017 Commonwealth Fund's international comparison report ranked the Dutch health care system third in health care system performance among 11 high-income countries. The Netherlands belong to the top-ranked countries, only the UK and Australia perform better. The Dutch health care system excels on access (first place), equity (second place) and Care process (fourth place), but needs improvement in administrative efficiency (ninth place) (Schneider et al., 2017). The top-ranks in access and equity point-out the pillars of the Dutch health care system, which is based on solidarity.
The Dutch health insurance act, enforced in 2006, reformed the Dutch health care system by the introduction of regulated competition between insurers. It moved from the dual system of mandatory public insurance and voluntary private insurance to universal mandatory private health insurance. It guarantees care for every citizen as described in the universal standardized benefit package (in Dutch 'het basispakket'). This includes, amongst others, hospital care, general practitioner care, medical aids, maternity care, medicines, ambulance and patient transport services and dental care for children till the age of 18. The main aim was to combine competition and incentives for efficiency while simultaneously maintaining equity (Schut & Van De Ven, 2011).

Within this regulated competition framework, health insurers are free to compete on price (premium) and quality (provider contracts) while the government safeguards affordability and accessibility with regulation. Such regulation entails open-enrolment, premium-rate restrictions, standardization of the benefits packages and risk equalization. Since the Dutch health insurance is characterized by open enrollment, enrollees are free to change health insurance and packages at the end of each year (Zorgwijzer, 2020). For the last eight years between 6% and 7% of the Dutch population switched insurer (Vectis, 2020). This number is relatively small, but nevertheless important, as it encourages competition between health insurers. Evaluation of the health insurance act shows that regulated competition can be combined with equity objectives, but on the premise of adequate risk equalization to prevent risk selection and indirect equity-harming long-term investment decisions by insurers (diverting health care resources for unprofitable insureds) (Schut & Van De Ven, 2011; Van Kleef et al., 2013; Withagen-Koster et al., 2018).

Although, the health insurance act ensures access and equity of health care and aims to provide insurers incentives for efficiency and quality of care, its financial sustainability is under pressure. Health care demand has increased substantially in complexity, caused by an increase in chronic diseases of sick and elderly, and in size. In 2020, the Dutch health care expenditure reached a value of more than 100 billion euros, an increase of more than €10 billion from 2018 (€87 billion) and €33 billion from 2008 (€67 million). This equals roughly to a five percent increase in total costs per year. The total health care expenditure per capita rose from €4.725 in 2008 to €5.863 in 2018 to €6.660 in 2020. An increase of almost €2.000 in the last two years (Statista, 2021). Health care expenditure is strongly concentrated, with long term care as the most concentrated expenditure. As the overall costs of health care are paid by everybody due to the solidarity principle, this may strain the equity pillar of the Dutch health care system (Bakx et al., 2016).

Rapid rising health care expenditures may pressure the Dutch health care system and its objectives. Reducing waste of health care resources, caused by inappropriate use, is urgent and necessary in making the Dutch health care system future-proof, according to the Dutch Health Care Authority and the Dutch Health Care Institute (2020). COVID-19 has made repression of care an urgent subject, but under normal circumstances repression of care due to inappropriate use had already become a returning matter in daily practice. Inappropriate use of health care resources entails the use of medical specialist care when primary care is sufficient, the underuse of innovation (e-health) and lack of prevention. Prevention of care (or the lack of) relates to care that was not needed in the first place. Stimulating healthier lifestyles and environments could be used as a tool to counteract waste of health care resources and repression of care. In addition to the financial perspective on the health care sector and the need to repress rising health care costs, societal and quality of life perspectives shed light on another need: the need to shift the focus of the health care sector from sickness and care to health and behavior. The number of people with chronic diseases will surpass the number of people with temporary illness in 2020 (Raad voor de Volksgezondheid en Zorg, 2010). This has drastic unfavorable consequences on different aspects of life and society, e.g. restricting societal participation and unequal chances. Hence, prevention of chronic diseases and stimulating healthy life styles plays a crucial role in this movement. For appropriate use of care and moving to a health care sector that is focused on the behavior and health of people, it is important that every involved party fulfills their role properly.

One of the parties involved are health insurers. The role of the health insurer is to act as careful purchasers of care, obliged by law under the Dutch Care Insurance act. They play an important role in containing health care costs, including investing in health prevention and innovation (Zorgwijzer, 2020). An example of such investment is the initiative ‘Keer diabetes om’; a life-style intervention aiming to eliminate obesity. Such initiatives seem desirable for an insurer as it prevents unnecessary medical costs in the future. However, currently evidence exists that insurers face contradicting financial incentives to invest in health improving actions (Nederlandse Zorgautoriteit & Zorginstituut Nederland, 2020). This subject will be discussed in more detail under *2.4 Unpriced risk heterogeneity and the prevention paradox.*

2.2 The health insurance financing scheme

Government regulation and competition in the health insurance market may create unintended market mechanisms that harm equity. As insurers are not allowed to risk-rate their premiums, risk equalization is needed to compensate competing insurers for predictable health care expenditure between high- and low-risk insureds. Without accurate risk equalization, insurers may be susceptible to risk selecting. Risk selection can be defined as behavior by consumers or insurers to exploit unpriced risk heterogeneity and break risk sharing agreements, which is unfavorable (Withagen-Koster et al., 2018). The main purpose of the Dutch Risk Equalization Model is to reduce incentives for risk selecting, create a fair playing field and stimulate careful purchasing of health care (Schut & Van De Ven, 2011; Van de ven & Ellis, 2000; Van Kleef et al., 2013). Health insurers receive or pay a contribution from the Risk Equalization Fund (REF), ideally, reflecting the predicted financial risk they run on their pool of insureds.

The financial flows to and from the REF under the Dutch Health Insurance Act are shown in Figure 1. Dutch citizens are required to pay a community-rated premium to their chosen health insurer, that is expected to cover 50% of the total health care expenditure for insurers. Additionally, they are required to pay an income-related contribution to the REF, covering the other 50% (Schut & Van De Ven, 2011). Every year, the Ministry of Health, Welfare and Sport estimates the total health care expenditure budget and the nominal insurance premium. For 2018, the total expenditure was estimated to be €48.7 billion and, subsequently, €46.0 billion for health insurers. The nominal insurance premium was set equal to €1,315 for the basic health insurance package. As health insurers are free to set their own premium to allow for competition, the average premium in 2018 was €1,362 with a deductible of €385 (Rijksoverheid, 2019). The differences in premium rates show the relative efficiency of insurers in terms of operating expenses, contract negotiations with care providers, collective insurance discount, uncollectable premiums, etc. The premium rate competition aims to stimulate insurers to act as careful purchasers of care for their insured (Kanters et al., 2013).

The money transfer between the Risk Equalization Fund and the insurer for insureds aged above 18 depend on the contribution calculated by the Risk Equalization Model minus the insureds out-of-pocket payments consisting of the premium rate and predicted deductible expenditure. The risk equalization contributions are determined by three different models for different types of healthcare payments: somatic healthcare, mental healthcare (GGZ) and out-of-pocket payments (Cattel et al., 2017). As this paper only focuses on the somatic healthcare model from 2018, this model will be elaborated on.

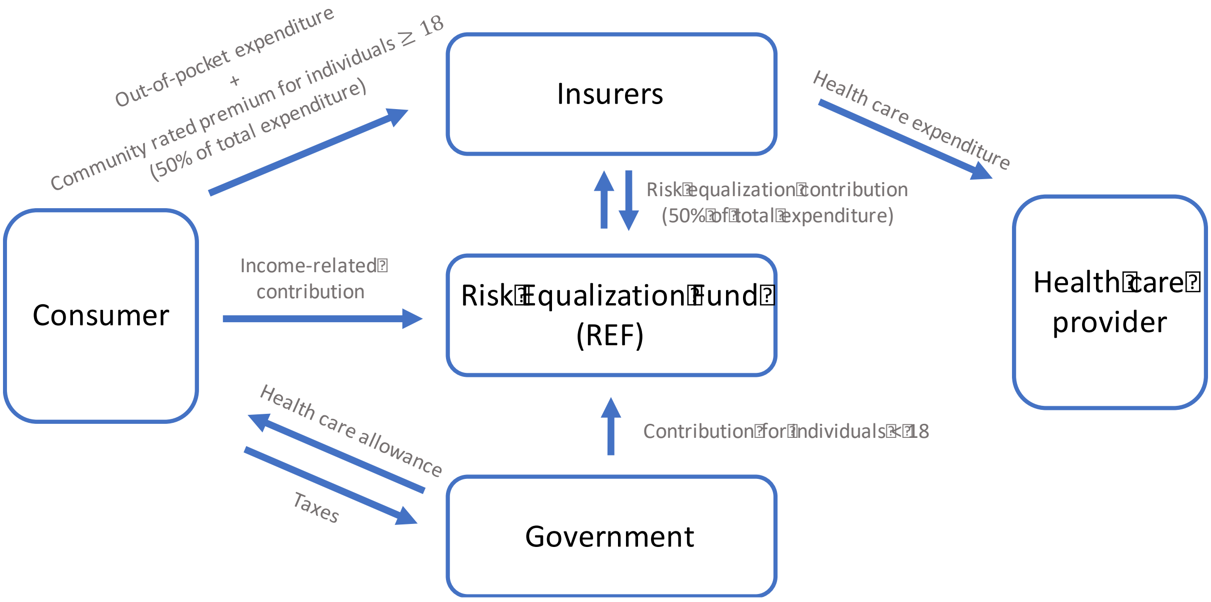


Figure 1: Financial flows of the Health Insurance Act (source: (Rijksoverheid, 2019))

2.3 The Risk Equalization Model

Health insurers receive an ex-ante contribution from the REF based on an estimation of the risk characteristics of their insured. Ex-ante means that the amount of the contribution is determined before the concerning calendar year. It exposes the insurer to financial risk, since he has to efficiently balance actual health care expenditures with the pre-determined REF contribution and premium income. The insurer keeps the difference between their income and actual health expenditure, which incentivizes effective and efficient purchasing of care (MinVWS, 2016). Besides ex-ante risk equalization, ex-post mechanisms are used to adjust the ex-ante contribution according to the actual risk characteristics of insureds in that calendar year.

The essence of the REF is to create a fair level playing field between insurers to keep these financial accountability incentives for efficiency in place. Insurers experience variation in health spending due to variation in risk of their insured population, for example in age and morbidity. To predict the risk profile of insured, 12 parameters are used in the 2018 Risk Equalization Model for somatic care. This accumulates to 193 different types of risk classes. Some parameters are direct proxies for health status, such as age, gender and variation in health. Some parameters strongly relate to health, such as socio-economic status or the number of persons per address. The parameters are incorporated in the model as dummy variables. (Cattel et al., 2017). An overview of the parameters, risk classes and equalization contributions in the 2018 model can be found in Table 1. The most relevant parameters for this research are age and gender, pharmacy costs groups and diagnostic costs groups. Other parameters will be discussed briefly.

Age and gender

The risk equalization model includes 42 risk classes for the parameter age and gender. As people grow older, health deteriorates and health care expenditure rises. This parameter takes the cost pattern of men and women separately into account since these differ significantly from each other. For example, pregnancy and birth for women drive amongst others the differences in cost between men and women aged 20-40. Information on age and gender are delivered by the insurer.

Pharmacy costs groups (PCG)

As a direct health indicator, PCG classifies insureds into cost groups based on pharmaceutical use in the previous year (t-1). It aims to indicate chronically ill insureds on the premise of their extramural pharmaceutical declarations that are prescribed for a particular chronic condition. Thresholds concerning the pharmaceutical dosage in the preceding year, e.g. 181 standard daily dosages (enough to use for half a year), must be met before categorization takes place in any of the PCG's. Insureds can be classified in multiple PCG's.

Diagnostic costs groups (DCG)

DCG classifies insureds based on (intramural) hospital diagnostic information in the previous year (t-1). The Dutch Health Care Institute classifies the diagnostic information from the insurer into diagnostic treatment combinations (DTC's), also referred as DX-groups. Diagnostic treatment combinations are subsequently classified into DCG risk classes. DCG risk classes cluster chronic conditions into homogenous cost groups. Insureds are first classified into one of the 16 primary DCG's. Individuals with multiple diagnoses can also be diagnosed in the secondary DCG, a new parameter in the Risk Equalization Model of 2018. Classification happens in the same way, based on remaining DX-groups. If individuals are eligible for multiple DCG's, the DCG with the highest rank and, therefore, the highest contribution is used in the Risk Equalization Model.

The remaining parameters, that are of less importance in this paper, can be distinguished into three groups: health care usage, socio-demographic characteristics and cost-based. The first group based on health care use includes the durable medical equipment costs parameter (DMCG), which relates to the use of a medical device for a particular chronic condition in the previous year (t-1). The physiotherapeutic costs group parameter uses physio and therapeutic therapy declarations for chronic diseases in the previous year (t-1) and the last parameter classifies insureds into 8 risk classes based on the costs of extramural nursing and personal care in the previous year (t-1).

The second group of parameters are based on socio-demographic characteristics. The parameter source of income interacts with age and classifies insureds into seven cost groups based on their type of occupation. The parameter region does not relate to geographical regions, but the clustering of postal codes. The clustered groups are based on care provision, socio-economic situation, western immigrants and other health related differences. Socio-economic status interacts with age and relates to the total income of a household (very low, low, average and high) in the current year (t). The number of people per address parameter distinguishes insureds that live in a long-term care institution, are singe households or fall into the 'others' category.

The last group of parameters are based on health care costs. The Multiple-year high costs (MHC) is used a risk parameter to identify insureds with three times successive high health care costs in the top-15% or less in the previous three years (t-1, t-2 and t-3) (Cattel et al., 2017; MinVWS, 2016; Van Kleef et al., 2013).

Parameter	Number of risk classes	Smallest contribution	Largest contribution
(1) Age/gender	42	€1,754.94	€9,646.47
(2) Pharmacy costs groups (PCG)	34	€-294.82	€405,406.85
(3) Primary diagnostic costs groups (pDCG)	16	€-202.55	€53,538.62
(4) Secondary diagnostic costs groups (sDCG)	8	€-90.16	€58,633.82
(5) Durable medical equipment costs groups (DMCG)	11	€-51.03	€30,460.82
(6) Source of income (SoI) * age	25	€-231.86	€1,947.69
(7) Region	10	€-43.27	€65.90
(8) Socio-economic status (SES) * age	12	€-277.64	€526.01
(9) People per address (PPA) * age	13	€-4,632.54	€11,685.00
(10) Multiple-year high costs (MHC)	9	€-570.63	€44,194.51
(11) Physiotherapeutic costs group (PHCG)	5	€-22.03	€10,200.47
(12) Costs of extramural nursing and personal care	8	€-185.42	€51,378.51

Table 1: Parameters, number of risk classes and contributions under the 2018 Dutch Risk Equalization Model (source: (Cattel et al., 2017))

These parameters are sophistically developed by the Dutch Ministry of Health and have been under constant revision through the addition or removal of parameters and classes to increase prediction. The monetary value of each risk class is re-estimated every year based on new available data about health care costs, demographic composition of insurer population and epidemiology development. In this paper, these risk parameters will be treated as given. The advantages and disadvantages of the design of certain parameters will not be elaborated on.

The Risk Equalization Model has improved substantially since its introduction in 1993, when only the interaction of age with gender was used as a risk adjuster variable. The 2020 model explains approximately 34% of the variance in health care expenses, compared to 30% for the 2012 model and 22% for the 2004 model (Cattel et al., 2020; Van De Ven et al., 2004; Van Kleef et al., 2013). The 2012 model improved by including social-economic and previous high health care cost parameters to the already existing parameters: region, source of income, PCG and DCG. The 2018 model has been extended with five more parameters to increase health expenditure prediction. Van Kleef et al. conclude that improvement of the Risk Equalization Model reduces under- or over-compensation, but simultaneously, could reduce incentives for prevention and efficiency. They also found that the 2012 model still substantially undercompensated all 18 high risk groups used in the study. They found an average under compensation of more than €400 for individuals with a chronic condition. This leaves insurers with the incentive to select low-risk individuals to prevent under compensation.

2.4 Unpriced risk heterogeneity and the prevention paradox

Perfect risk equalization would eliminate incentives for risk selection completely by eliminating any unpriced risk heterogeneity, hence any over or under compensation. The expected net revenue for each insurer would be equal. Unpriced risk heterogeneity and risk selecting incentives have adverse effects and may lead to worse quality of health plan designs for high-risk individuals, price distortions, less efficiency in the provision of care and lower equity and access of care (Withagen-Koster et al., 2018). The Dutch risk equalization model has therefore been developed in a sophisticated model over time to mitigate risk selecting incentives.

Although annual surveys from 2006 - 2009 reveal that an increasing proportion of high-risk individuals fear health insurers are unwilling to offer them supplementary health insurance, no substantial empirical evidence for risk selecting has been found yet. Other research shows that the risk equalization model is not able to fully eliminate unpriced risk heterogeneity and, simultaneously, risk selecting incentives. Van Kleef, Van Vliet & Van de Ven (2013) found that the 2012 model was not able to adequately predict the risk profile of high-risk individuals. Withagen-Koster, Van Kleef and Eijkenaar found evidence of predictable profit and losses for both morbidity and non-morbidity groups under the 2016 model and that this unpriced risk heterogeneity increases with health care spending (morbidity groups). Lastly, Eijkenaar, Van Vliet & Van Kleef R. C. (2018) found significant under compensation of several subgroups in the 2017 model. They suggested the introduction of prior use of medical equipment and physiotherapy risk adjusters to improve prediction of the model. Both parameters are included in the 2018 model. Due to flaws in the Dutch Risk Equalization Model, overcompensation of low-risk individuals and under compensation of high-risk individuals leaves insurers with incentives for risk selection. Hence, further improvement of the risk parameters serves to mitigate risk selecting incentives. In regards to obesity, Eggleston and Bir (2009) find substantial risk selection incentives for cardiac care and diabetes, obesity-related conditions, using U.S.A. managed care medical and pharmacy spending data from 2001 and 2002.

Mitigating risk selecting by improving risk equalization, may also imply less incentives for prevention. Hence, preventing risk selection requires compensating for differences in health status, but rewarding unhealthy life styles discourages prevention and improvement of health. In such case, the additional costs made for preventative actions are not rewarded with additional risk equalization revenues as those revenues are based on the insured's health status and not on the prevention efforts. Meanwhile if costs for unhealthy individuals are not sufficiently compensated with risk equalization revenues, the financial incentive exists for insurers to engage in risk selection or health-promoting activities to exploit this unpriced risk heterogeneity. Hence, improving risk equalization may penalize prevention efforts for insurers. Kanters et al. (2013) call this trade-off a 'prevention paradox'; preventing risk selection requires perfect risk equalization, but preventing unhealthy lifestyles may benefit from imperfect risk equalization. However, little research is known about the interrelation between risk selecting and prevention incentives under (imperfect) risk equalization.

Kanters et al. (2013) introduced and explored this new prevention paradox. They analyzed life time health care costs and risk equalization contributions for three hypothetical cohorts: obese, smoking and healthy living. Their results show that the healthy living cohort is most attractive for insurers, compared to the smoking or obese cohort under the 2008 risk equalization model. However, they also argue that the small differences in the net balance (risk equalization contributions minus health care costs) for the three cohorts is so small, that it may reduce the incentive to engage in preventive actions and increase incentives to invest in cheap risk selection. For example, the €83 calculated difference in net revenue and costs per life year between the obese and healthy living cohort might not be enough to outweigh the costs of an intervention treatment and rather stimulate risk selection. On the basis of this knowledge, this paper will replicate the research of Kanters et al. under the more sophisticated risk equalization model of 2018 with 5 additional risk parameters and continue this debate by examining the effect of different levels of hypothetical obese prevention on insurer's net revenue.

Improvement of the risk equalization model may hinder prevention efforts for insurers. Then the question arises how the risk equalization scheme can be designed differently to stimulate health improving investments by insurers. Eggleston, Ellis and Lu (2012) demonstrate the incentive trade-off between selection and prevention in a theoretical model and argue to combine risk equalization contributions with pay-for-performance indicators linked to prevention to keep incentives in place. They also argue that prevention can serve as a selection tool to incentivize high-risk individuals to stay and for low-risk profiles to switch insurer. In such case, the insurer is better able to target its disease management on higher-risk profiles. All on the condition that prevention efforts are rewarded by a pay-for-performance bonus which offsets the insurer's lower net revenue. Although the model provides a theoretical framework, it lacks empirical evidence. This paper aims to emphasize the need for further empirical research on such models by showing the extent to which prevention is stimulated, or rather discouraged, under the current risk equalization model.

2.5 Obesity prevention

Obesity is a common, complex and costly disease, but more importantly a preventable disease. Worldwide obesity has nearly tripled since 1975. In 2019 half of the Dutch population is overweight and almost 15% obese (Volksgezondheidenzorg.info, 2021). Obesity involves an excessive amount of body fat caused by a constant positive energy imbalance. Obesity and being overweight are major risk factors for developing non-communicable diseases, such as cardiovascular diseases, diabetes, musculoskeletal disorders and certain cancers. Overweight and obesity, with their related diseases, are largely preventable with lifestyle changes as the easiest choice (WHO, 2020). It is estimated that in the U.S.A. the health care costs incurred by severe obese individuals before undergoing bariatric surgery is twice as much as an average healthy person (Keating et al., 2012). Regarding the high costs and its preventable character, investments in preventing obesity can be of great potential in improving public health and reducing wasteful use of health care resources.

The most accessible, but less effective method for prevention or deterioration of obesity are life style interventions. Costs can range from €150 tot €1150 (Bemelmans et al., 2008). Since January 2019, a combined lifestyle intervention is part of the standard benefit package in The Netherlands (in Dutch 'Gecombineerde leefstijlinterventie'). To be eligible, individuals need to have a BMI $\geq$ 30 or a BMI $\geq$ 25 with increased risk of cardiovascular diseases or diabetes type 2. It should be noted here that the effectiveness of the intervention also depend on external factors, such as emotional capabilities, social support, socio-economic status and living situation. This makes life style interventions not a one-size-fits-all treatment with inconsistent results (Bos et al., 2019; Nordmo et al., 2020).

A more effective, invasive treatment with surgical risks is bariatric surgery (Courcoulas et al., 2020). Surgical costs are €6515 in 2020 (Nederlandse Zorgautoriteit, 2020). Research shows that bariatric surgery induces long-term durable weight loss, remission of type 2 diabetes with salutary effects on other comorbidities and reductions in mortality (Pories, 2008). Since there exists conflicting evidence about the effectiveness of life style interventions for obesity and bariatric surgery has proven to be cost-effective, the latter preventive treatment will be used in this study (Yu et al., 2015).

As prevention of obesity and related diseases increase life expectancy, life-time health care costs will also increase. Van Baal et al. (2008) argue how obesity prevention decreases obesity-related life-time health care costs, but that this reduction is off-set by an increase in health care costs related to prolonged life. In such case, obesity prevention will still reduce wasteful use of health care resources and improve public health, but, simultaneously, shift the burden of cost containment to other (end-of-life) diseases. This may influence insurers' financial incentives to invest in prevention under the risk equalization scheme. High end-of-life health care costs could off-set the financial gains from the health-improving investment. Accurate risk equalization could prevent this. In this paper, life-time health care costs and risk equalization contributions will be taken into account to examine the effect of prolonged life and risk equalization on incentives for prevention.

Chapter 3. Research methods

This section describes the methods and data used to examine financial incentives for risk selecting and prevention for a hypothetical obese and healthy-living cohort. The research design consists of three parts. First, hypothetical life style related cohorts are simulated using the RIVM Chronic Disease Model and epidemiological population data. Secondly, risk equalization contributions and healthcare costs are linked to the RIVM-CDM predicted survivors in the cohorts to calculate insurer's net profits. Data from the Cost of Illness study is used to determine disease costs. Actual insurer data from the ZiNL database is used to determine risk equalization contributions. Lastly, hypothetical prevention levels are used to simulate the effect of obesity prevention on insurer's net revenues.

Financial incentives for prevention and implicitly for risk selection are examined under the 2018 Dutch Risk Equalization Model from the insurer's perspective. Differences between revenues and costs between a hypothetical obese and healthy living cohort are determined to examine the financial incentives in relation to improvement in the model from 2008, used in the paper by Kanters et al. (2013). Additionally, differences in revenues and costs were calculated for the obese cohort with a simulated bariatric surgery treatment as prevention method. Revenues relate to the insurer's risk-adjusted contributions calculated under the 2018 somatic Risk Equalization Model. Costs relate to insureds somatic health care costs that are borne by the insurer under the standard benefit package. The net balance of each cohort (revenues minus costs) determines its relative attractiveness to the insurer. If the net balance is most favorable for the healthy living cohort or the obese cohort with the prevention treatment, risk selection or prevention might be profitable for the insurer. The net balance between cohorts will be compared per life year and lifetime.

3.1 RIVM Chronic Disease Model

Since lifelong data about lifestyle related health care consumption and disease prevalence were not available, the RIVM Chronic Disease Model (CDM) was used to predict aggregate disease prevalence numbers and the life course of survivors in the cohort. The model was first introduced by Van Baal et al. (2006) to estimate the life expectancy of three life style related cohorts (healthy living, obese and smokers). In this research, only the RIVM-CDM output concerning the healthy living and obese cohorts will be used. The RIVM-CDM estimates the number of survivors and the disease incidence, prevalence and mortality rates over time for each cohort. The number of survivors, the cohort's prevalence of obesity related diseases (e.g. diabetes, stomach cancer, arthrosis) and the prevalence of other causes of disease is used to determine health care costs. Subsequently, the prevalence of diseases is used to classify insureds into risk classes under the 2018 Risk Equalization Model in order to calculate the total risk-equalization revenue for the insurer each year. Using a simulation model enables the possibility to calculate health care costs and risk-equalization contributions over a lifetime period without observing actual individuals. Additionally, population mortality, incidence, prevalence and relative risks for health style related diseases are the few input parameters the RIVM-CDM needs, which makes gathering data not burdensome and the results easy to reproduce. RIVM-CDM simulated disease prevalence rates and the number of survivors have been used before to predict (lifetime) health care costs (Hoogenveen et al., 2009; Van Baal et al., 2008) and risk equalization contributions.

The RIVM-CDM is a deterministic simulation model with time-continuous differential equations that predict the life-course of cohorts due to changes in risk factor classes (e.g. normal weight, overweight and obese) and changes between disease states (e.g. chronic heart failure, diabetes, stomach cancer, etc.). Two different cohorts are used in this study; a healthy living cohort consisting of men and women aged 20 with normal weight and an obese cohort, consisting of men and women aged 20 with a BMI above 30. The diseases modeled in RIVM-CDM are related to obesity and can be found in the Appendix. Transitions between risk-factor classes over time are not taken into account, meaning that the cohort is closed in that sense. The 500 men and 500 women starting in the obese cohort at the age of 20, remain in the obese cohort till they are deceased. The choice of 500 men and 500 women has also been used in Van Baal et al. (2008) and Kanters et al. (2013) and makes comparison of results possible.

RIVM-CDM input data as used in Van Baal et al. (2006) consisted of population mortality, excess mortality and incidence rates for men and women from 2004. Furthermore, it included risk factors for each risk class related to the diseases modeled. The input data lacked some parameter values. Cause specific mortality rates per disease were retrieved from Statistics Netherlands (CBS) and is based on the registry for underlying causes of death (CBS, 2020). Diseases in this registry are labeled with ICD-10 codes (International Classification of Diseases). The relevant ICD-10 codes for this study can be found in Table A1 in the Appendix. Prevalence rates are based on data from the Dutch Cancer Registry (NKR, 2020) and the second national study for diseases and general practitioner practices from Nivel (van der Linden et al., 2004). The latter paper contains ICPC-codes (International Classification of Primary Care) to label diseases. ICPC classifications can be found in the Appendix (Table A1). As the input data only consists of data till the age of 86, simulations could be made for the cohorts until that age. This differs from the research done in Kanters (2013), who simulated up to all ages.

As the input data stem from 2004, additional parameter values were also retrieved for the year 2004. A summary file was available with average values of all parameters for 15-year age classes used in Van Baal et al. (2006). Comparison of these average input values with the cause specific mortality and prevalence rates, retrieved from external registries, showed no significant deficiencies. As the prevalence rates from the Nivel study are based on the year 2001, the assumption was made that these values did not significantly change over time till 2004 and could be used in this study. Ideally, all input values would be based on the year 2018 for validity and accuracy. However, since data on excess mortality, incidence rates and relative risks are not publicly available per life year and gender for 2018, input values from Van Baal et al. (2006) were used in this analysis. This impacts the representativeness of the cohorts if input values changed over time from 2004 to 2018. Comparison with average disease prevalence and incidence rates from Nivel (2019) for the year 2019 showed roughly no substantial change between cardiovascular diseases from 2004. Cancer rates used in the RIVM-CDM were almost twice as low in 2019. Furthermore, COPD, arthrosis and dorsopathies were in 2004 almost twice as high compared to 2019. These differences need to be taken into account when assessing the external validity of the results. Important to recall is that Nivel's average disease incidence and prevalence rates were only publicly available for the year 2019 during the conduct of this research. The assumption was made here that population rates in 2019 are representative for 2018.

The RIVM-CDM consists of two parts: initializing parameter values and the model simulation. A detailed explanation of the initialization steps with corresponding formulas can be found in Van Baal et al. (2008). The simulation part to compute disease prevalence rates and the number of survivors for the obese and healthy living cohort are explained below. Some initializing formulas required additional steps which are not shown in Van Baal et al. (2008). These extra steps can be found in the Appendix

(Formula A1). The yearly changes in prevalence rates per disease are described as a function of relative risks, incidence and excess mortality rates. Incidence rates are derived by multiplying the relative risk of a disease for a certain cohort with the baseline incidence rate. Relative risks for the healthy cohort are equal to one. Formula (1) shows the change in disease prevalence rate for disease *d* over time for a cohort with a specific risk class (normal weight, overweight, obese). The change in the prevalence rate for a healthy living or obese cohort of a certain disease depends on the corresponding incidence rate minus the disease's excess mortality times the disease prevalence rate at time *t.* Subsequently, the disease prevalence at time *t* is subtracted to calculate the actual change between time *t and t+1.* The rationale behind this formula with the example of diabetes as disease is that the cohort specific incidence rate of diabetes determines the new prevalent diabetes cases. The excess mortality of diabetes decreases the number of diabetes patients, which depends on the actual prevalence of diabetes in the cohort. Age and sex indices are omitted in the formula (van Baal et al., 2006).

$$(1)\ \frac{\mathrm{dp(d|t)}}{dt} = (\mathrm{i(d)}_0 * RR(d|b_k) - em(d) * p(d|t)) * (1 - p(d|t)$$

$$\mathrm{p(d|t)} = prevalence\ rate\ disease\ d\ at\ time\ t$$

$$\mathrm{i(d)}_0 = baseline\ incidence\ rate\ disease\ d\ for\ healthy\ living\ cohort$$

$$RR(d|b_k) = relative\ risk\ for\ disease\ d\ for\ BMI\ class\ k$$

$$em(d) = excess\ mortality\ rate\ disease\ d$$

The yearly number of survivors in the cohort depends on the relative risk of other causes of disease than the 22 diseases modeled in the RIVM-CDM and other causes of disease mortality. This baseline of other causes of mortality depends on the relative risks of all risk classes for other cause mortality and total mortality. Formula (2) shows the change in number of survivors of the cohort over time. The number of survivors depends on the cohort's relative risk for other causes of disease times the mortality rate for other causes of disease times the number of survivors. The attributable mortality of each disease modeled in the RIVM-CDM times the disease prevalence rate and number of survivors is summed up and subtracted from the previous part. The rationale behind this formula is that the mortality of the obese related diseases can be substituted with non-obese related disease mortality which needs to be taken into account.

$$(2)\ \frac{\mathrm{dN(t)}}{dt} = RR(oc|b_k) * \ m(oc)_0 * N(t) - \ \sum_d am(d) * p(d|t) * N(t)$$

$$\mathrm{N(t)} = Number\ of\ survivors\ at\ time\ t$$

$$RR(oc|b_k) = relative\ risk\ for\ disease\ d\ for\ BMI\ class\ k$$

$$m(oc)_0 = baseline\ other\ causes\ mortality\ rate\ for\ healthy\ living\ cohort$$

$$am(d) = attributed\ mortality\ rate\ disease\ d$$

The prevalence of other diseases (diseases unrelated to obesity and smoking) solely depends on the number of survivors in the cohort. As the input and output parameter values of the RIVM-CDM are aggregate level data, further calculations are made at the group level and not at the individual level. The outcome of the RIVM-CDM, 22 disease prevalence rates and number of survivors, can be linked to health care costs from the Cost of Illness study and risk parameters in the 2018 Risk Equalization model to determine insurer's net revenues.

3.2 Coupling health care costs and risk equalization contributions to insureds

3.1.1 (Lifetime) health care costs

Health care costs per disease, age and sex are retrieved from the Dutch Cost of Illness study 2003 (COI) (Slobbe et al., 2006). In this study, a top-down method was used where total health care costs in the Netherlands are attributed to the main diagnosis of the patient to avoid double counting. It should be noted that, especially at older ages, the need for health care could have a variety of causes. All costs will be attributed to the main diagnosis, while the underlying diseases, which are for a large part the reason for the initial poor health, remain unnoticed, e.g. diabetes. Hence, these particular disease costs may be underestimated. This also applies to mortality rates of underlying diseases. Diabetes mortality rates are often underestimated (Roglic et al., 2005). Lifetime and annual health care expenditure per cohort are estimated by multiplying RIVM-CDM disease prevalence rates with the COI annual costs per disease per patient. Costs for diseases not incorporated in the RIVM-CDM depend only on the number of survivors in the cohort. Formula (3) shows the calculation of life time health care expenditure (Van Baal et al., 2008).

(3) $\mathrm{lhc} = \sum_t N(t) * \{co + \sum_d p(d|t) * cp(d)\}$

$\mathrm{lhc} = Lifetime\ health\ care\ costs$

$\mathrm{co} = Annual\ health\ care\ costs\ per\ person\ for\ all\ other\ diseases$

$cp(d) = Annual\ costs\ per\ patient\ having\ a\ CDM\ modeled\ disease\ d$

As COI health care costs need to be equalized to the price level of care in 2018, total health care costs used in the 2003 COI study is linearly scaled to the total macro budget (BKZ) in 2018. The macro budget equaled €77.7 billion in 2018 (MinVWS, 2017). As only health care costs borne by the insurer under the somatic risk equalization model are relevant in this study, long term and mental health care expenditure are removed from the macro budget before equalizing COI costs with the 2018 macro budget. Eventually, the macro budget equaled €42.0 billion, including premium and deductible revenue. Long term and mental health care do not follow a linear cost pattern; e.g. long term care is more concentrated at higher ages and mental health care is more concentrated at women than men. Consequently, the patterns of actual insurers' care expenditure under the basic insurance package for different age-classes in 2018 is used to non-linearly scale the COI health care costs (Vektis, 2018). Costs under the basic insurance package include mental health care costs and are therefore first removed from the insurer's health care costs.

3.1.2 Risk equalization contributions

RIVM-CDM disease prevalence rates and number of survivors for the obese and healthy living cohorts are used to predict yearly and lifetime risk equalization contributions. Disease prevalence rates times the number of survivors in the cohort determines the number of people in each risk class. As these disease predictions are made at the group-level, only three risk parameters directly linked to diseases could be used in this study to estimate the insurer's contributions (age and sex, pDCG and PCG). Individual data related to other risk parameters, that are not direct proxies for health, could not be derived from the RIVM-CDM, e.g. SES, PPA or region. Hence, the average risk-adjusted contribution for each parameter based on insured data from 2018 is used instead. Formula (4) denotes the total risk equalization contribution for a cohort at time t as a function of the summation of the separate risk parameters:

$$(4)\ RE(t) = \sum_{c=1}^{28} age\_sex_c * n(t)_c + \sum_{c=1}^{16} pDCG_c * n(t)_c + \sum_{c=1}^{34} PCG_c * n(t)_c + \sum_{p=1}^{10} avg\_cont_p * n(t)$$

$\mathrm{RE(t)} = Risk\ equalization\ contribution\ at\ time\ t$

$n(t)_c = number\ of\ survivors\ at\ time\ t\ in\ corresponding\ risk\ class\ c$

$age\_sex_c = payment\ for\ age\ and\ sex\ class\ c$

$pDCG_c = pDCG\ payment\ for\ risk\ class\ c$

$PCG_c = PCG\ payment\ for\ risk\ class\ c$

$avg\_cont_p = average\ contribution\ for\ risk\ parameter\ p$

The minimum and maximum parameter values are shown in Table 1. An extensive description of each risk class payment can be found in Cattel et al. (2017). RIVM-CDM disease prevalence rates cannot be directly linked to parameters in the risk equalization model, as not all prevalent individuals will be treated and, hence, will be classified in a disease related PCD or pDCG classification. As risk equalization revenues only depend on actual classifications of the insured, the ratio of PCG and pDCG classification to disease prevalence had to be estimated. Actual DCG classifications for the 2018 risk equalization model are obtained from the Dutch National Health Care Institute (ZiNL). Disease prevalence rates are obtained from the Netherlands Institute for Health Services Research (Nivel). pDCG classifications depend on the underlying DX-group classifications. Each DX-group classification describes a particular diagnostic treatment combination which can be directly linked to the modeled RIVM-CDM disease, which relates to obesity. An overview of the DX-group classifications per disease can be found in the Appendix (Table A2). The predicted volumes of pDCG classifications were divided by disease prevalence rates. Hence, the average number of pDCG classifications per prevalent person was derived. An overview of the ratios can also be found in Table A2 in the Appendix. Consequently, the number of survivors per pDCG risk class are derived by multiplying the average pDCG classification ratios with the RIVM-CDM prevalence rates.

At ZiNL, insurer's pharmaceutical declarations for their insureds are directly linked to PCG classifications. These declarations are stored in the ZiNL database but not suitable to use in this study. Hence, the PCG classifications resulting from the pharmaceutical declarations are used. The PCG classification volumes alone cannot be used to link obese related diseases to PCG volumes. For example, the volume of PCG class 'cancer' consists of all insureds that have had cancer medication prescribed, exceeding the 180 daily doses a year threshold, in the previous year. No distinction can be made in PCG volume between kidney cancer and breast cancer. Hence, in this study the pDCG classification ratio is used as a proxy to determine the average PCG classification per prevalent person. Due to the description of each PCG risk class, each modeled disease is linked to a relevant PCG class. The assumption is made here that intramural care (DCG) can act as a proxy for extramural care (PCG).

In reality, this assumption will most likely not hold as hospitalization often happens less frequently than pharmaceutical prescription. For example, hospitalization of a diabetes patient is less likely than receiving prescribed diabetes medication. Some PCG classes also reflect intramural care, such as cancer, transplantations or high costs classes. By combining the pDCG volume ratios with the disease prevalence rates and the number of survivors per cohort, the pDCG and PCG volumes and corresponding risk equalization contributions are found.

PCG and pDCG classifications unrelated to the diseases modeled in the RIVM-CDM depend only on the number of survivors in the cohort. The volume of DX-groups unrelated to obesity was used to determine the average number of unrelated pDCG classifications per individual. Consequently, this ratio was used to find the total volume of unrelated pDCG volumes per cohort. This ratio was also used to find the unrelated PCG volumes per cohort. The obesity unrelated ratios of pDCG's and PCG's were corrected for age and sex. The obesity related ratios of pDCG's and PCG's were not corrected as the RIVM-CDM already adjusts disease prevalence rates for age and sex.

Lastly, the sDCG is not explicitly used in this study. The rationale behind the inclusion of sDCG's in the risk equalization model is to increase the prediction of co-morbidities (Cattel et al., 2017). Classification depends on the remaining DX-classification(s) of the insured after classification for the DX-group with the highest pDCG. Since the RIVM-CDM does not take the prevalence of comorbidities into account, RIVM-CDM disease prevalence rates could not be linked to sDCG's. Hence, the population average sDCG payment adjusted for age and sex is used. The latter is also done for the other risk parameters that are unrelated to the modeled diseases in this study.

3.3 Hypothetical prevention in obesity

Bariatric surgery will be used as a frame of reference in terms of hypothetical health outcomes resulting from prevention or, better defined as, prevention of deterioration of diseases. Bariatric surgery is associated with reduced incidence of myocardial infarction (29%), stroke (34%), cancer in women (42%), and overall mortality (30–40%) (Singh et al., 2015). Evidence exists that bariatric surgery substantially reduces cancer incidence and cancer related deaths by 46% (Adams et al., 2009). Additionally, bariatric surgery would reduce diabetes remission by 45-95% (Vetter et al., 2012) and Cardiovascular heart failure on average by 11% for males and 14% for females (Ashrafian et al., 2008). From empirical evidence, it can be concluded that bariatric surgery, with the corresponding weight loss, has beneficial effects on all obesity related diseases in general. No indisputable consensus has yet been reached on the magnitude of the actual health benefits (Ashrafian et al., 2008). Health outcomes examined in studies heavily rely on the study design and other external factors, e.g. length of follow-up period, control size and type of treatment.

As the focus of this paper relates to financial incentives under the 2018 Risk Equalization model and not the effectiveness of bariatric surgery, RIVM-CDM computed prevalence rates for the obesity cohort will be altered with hypothetical prevention health outcomes. As almost all diseases are reduced by 50% or less after bariatric surgery, this will be used as the starting point for the hypothetical effect of bariatric surgery (Obesitaskliniek, 2020). Subsequently, a 5%, 10% and 25% reduction in the prevalence rates of obese related diseases will be used to simulate hypothetical obesity prevention effects. The different health outcomes will be used to study the relation between effectiveness of prevention and net revenue for insurers. Subsequently, insurer's minimum attractive investment can be determined, e.g. when will the net balance be zero. The actual costs for bariatric surgery in 2020 are €6515 and aftercare costs are approximately €1.800 in the first year, €800 in the second year and €300 in the third and fourth year (Federatie Medisch Specialisten, 2019). Important to mention is that reduction of mortality due to prevention is not incorporated here. This impacts life expectancy of the obese cohort as the number of survivors will not be impacted by the prevention. This is unlikely to occur in real life. By calculating the net balance per insurer, the effect of life expectancy on net revenue is removed. Additionally, the effect of prevention on increased health care costs and revenues due to prolonged life is not measured. In other words, no conclusions can be drawn for the lifetime of the whole obese cohort as this would yield no representative but rather misleading results. However, inferences can be made on the individual level since insured's net balance is not directly influenced by the number of survivors.

The aim is not predicting the net revenues of each hypothetical prevention level for bariatric surgery, but to examine the extent to which prevention needs to be effective to be profitable for the insurer under risk equalization. For example, a reduction of at least 90% in obesity related disease prevalence rates for a profitable balance between costs and revenues is unlikely to occur in real life. The minimal level of prevention in order for the insurer to be profitable, shows the prevention incentive under the 2018 Risk Equalization Model. Although outside this hypothetical setting, bariatric surgery health outcomes will most likely differ, this method can still be used to show which preventative efforts are needed for the insurer to have a profitable net balance, i.e. to be incentivized to invest in prevention.

CHAPTER 4. RESULTS

This section describes the empirical results found in the analyses. The structure of the methodology is also followed here and described in three steps. First, the simulated cohorts from the RIVM-CDM are described. Secondly, the health care costs, risk equalization contributions and net revenue for each cohort is quantified and illustrated. Lastly, different levels of prevention effectiveness in obesity are studied in relation to insurer's net revenue.

4.1 Life course and life expectancies cohorts

The life courses of the obese and healthy living cohorts are shown in Figure 2. As expected, obese individuals die at lower ages and have a lower life expectancy (LE) than healthy living individuals. This difference in mortality rate arises around the age of 55. As the RIVM-CDM's input data only contained epidemiological information till the age of 86, the life courses of the cohorts are simulated till that age. To estimate life expectancies for each cohort, age 86 is treated as an open-ended age interval in the life table of survivors. Dividing the number of survivors with the cohort specific predicted mortality rates at age 86 (RIVM-CDM), determines the remaining life years lived from the age 86. For illustration purposes, the dotted lines are an extrapolation of the survival curves based on van Baal et al. (2006).

At age 20, the remaining LE for obese individuals is estimated to be 59,1 years. At this age, the surface under the obese survival curve is 50% in Figure 2. On average, obese individuals are expected to live till the age of 79,1. Healthy living individuals are expected to live 4,9 years longer. They have a LE of 64,0 years at the age of 20, which means they are expected to live till the age of 84,0 on average. The life expectancies and survival curves for the separate male and female cohorts can be found in the Appendix (Graph B1 and B2, Table B1). These life expectancies and survival curves resemble the results of Kanters et al. (2013), van Baal et al. (2006) and Van Baal et al. (2008), who found a LE difference of 4,5 years between the two cohorts.

Figure 2: Survival curves for an obese and a healthy living cohort under the RIVM-CDM, each starting with 500 men and 500 women at age 20. Dotted lines are an extrapolation of the predicted survivors based on survival curves from van Baal et al. (2006).

4.2 Net revenue for each cohort

The disease prevalence rates and number of survivors for the two cohorts at each age are linked to disease-specific costs to determine the total health care costs for the insurer per year and lifetime. The obese cohort incurs higher disease prevalence rates over time. However, over the entire life course total health care costs for the healthy living cohort were the highest. Although, healthy living individuals incurred lower costs per person per year and over their entire life compared to obese individuals, this is off-set by the longer lifespan of healthy living individuals. As the healthy living live longer and therefore incur costs over a longer time horizon, health care costs for this cohort increases substantially at high ages.

Figure 3 shows the difference in total costs for the obese cohort compared to the healthy living cohort over age. Negative values indicate higher costs for the obese cohort and positive values indicate higher costs for the healthy living cohort. Up till the age of 70, total health care costs are higher for the obese cohort. Those costs are mainly driven by the high prevalence of life-style related diseases. For example, total diabetes costs for the obese cohort are more than ten times higher than the healthy living cohort at age 50. At high ages, the obese cohort incurred substantially less costs due to the relative decrease in the number of insureds (survivors) compared to the healthy living cohort.

From the start (age 20), annual health care costs per person are highest for obese individuals. This absolute difference between obese and healthy living increases over time. Till the age of 50, this difference is relatively small and about €175 per year. If individuals lived up till the age of 80, an obese individual incurred roughly €825 more health care costs than a healthy living individual per year. These figures and numbers resemble the results from Kanters et al. (2013) in the way that total health care costs are highest for the healthy living cohort and annual health care costs per person are highest for obese individuals. These differences do not correspond exactly to the values stated in Kanters et al. (2013). Most presumably due to the increased price level of health care from 2008 till 2018. Figures on total health care expenditure per cohort and survivor can be found in the Appendix (B3 & B4).

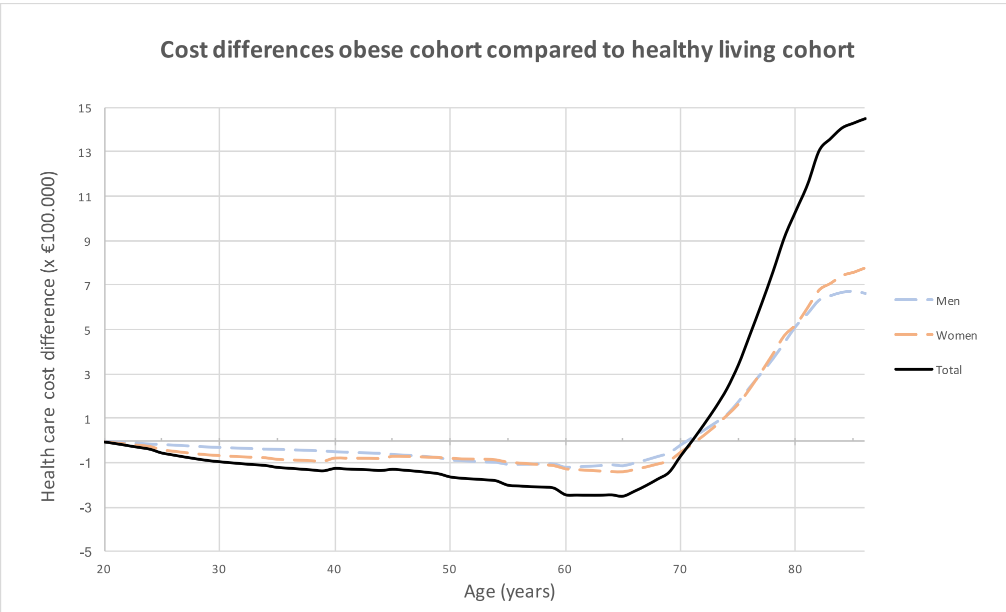


Figure 3: Health care expenditure differences of healthy living cohort compared to the obese cohort over time. Dotted lines depict differences within male and female cohorts. Black line depicts differences for total cohorts (men and women together). Negative values depict higher health care expenditure for obese individuals compared to the healthy living and vice versa.

Additionally, disease prevalence rates and the number of survivors are used to classify insureds into different risk classes under the 2018 risk equalization model. These classifications determine the RE revenues per year and lifetime for the whole cohort. Subsequently, these RE revenues per person can be compared between the cohorts. RE per person is highest for obese individuals at all ages, shown in Figure 4. These results resemble the findings of Kanters et al. (2013) in the sense that contributions follow the same pattern and remain highest for obese individuals. The age/gender risk parameter includes incremental contributions following 5-year age classes, which explains the step-wise upward trend. Until the age of 45, differences in risk equalization contribution is small and almost equal between obese and healthy living insureds. From the age of 50, insurers receive significantly more contribution for obese individuals. The difference in contributions between obese and healthy living increases with age, which is mainly due to differences in PCG and DCG classifications caused by the prevalence of obese related (diabetes, chronic heart failure, stomach cancer etc.) and unrelated diseases (all other diseases) modeled under the RIVM-CDM.

Figure 4 shows that, for example enrollees aged 50-54, insurers receive on average €42 more RE contribution for an obese insured than a healthy living per year. At age 80-84, this difference has increased to €919. If we compare these revenue differences with the previous cost differences at age 50-54 (€175) and 80-84 (€825), we see that at the former age insurers are undercompensated for obese individuals as opposed to the overcompensation at the latter age. Obese individuals become more profitable for insurers at high ages in comparison to healthy individuals. If we look at differences in total risk equalization revenues (Figure 5) and costs (Figure 3) between the cohorts, the same results are found.

Similar to health care costs, lifetime risk equalization contribution is also the highest for the healthy living cohort. Although risk equalization revenue per person is the highest for obese individuals, the higher total RE revenue for the healthy living cohort is mainly driven by the relative higher number of insureds at the end of life.

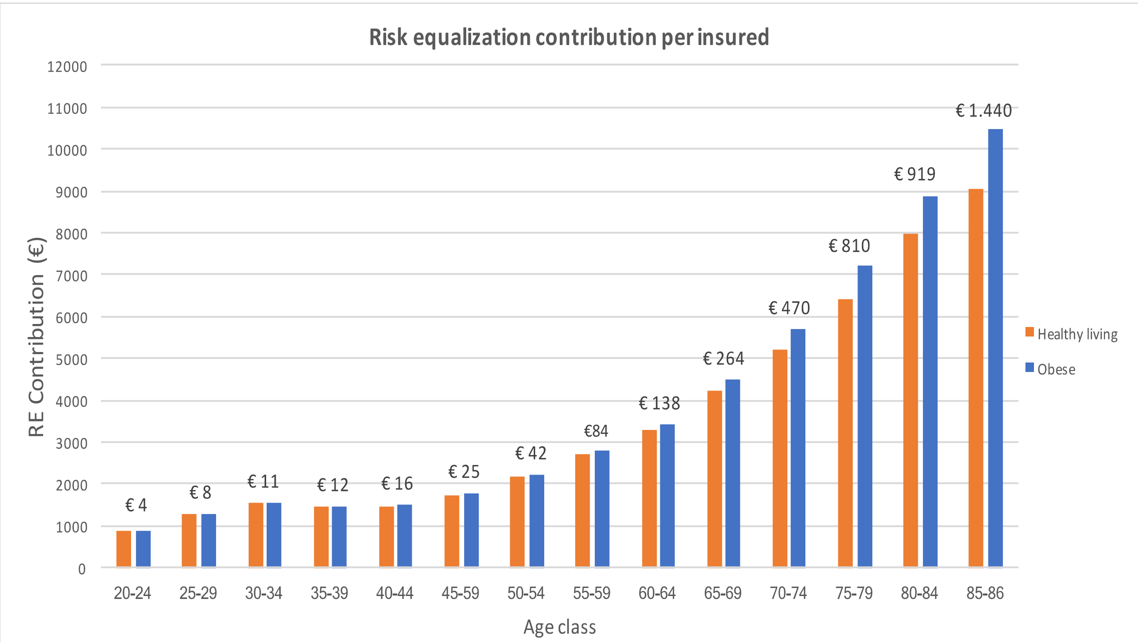


Figure 4: Risk equalization contribution per insured (survivor) in the obese and healthy living cohort per age class. Monetary values above the bins of each age class reflect the absolute difference in contribution (obese minus healthy living).

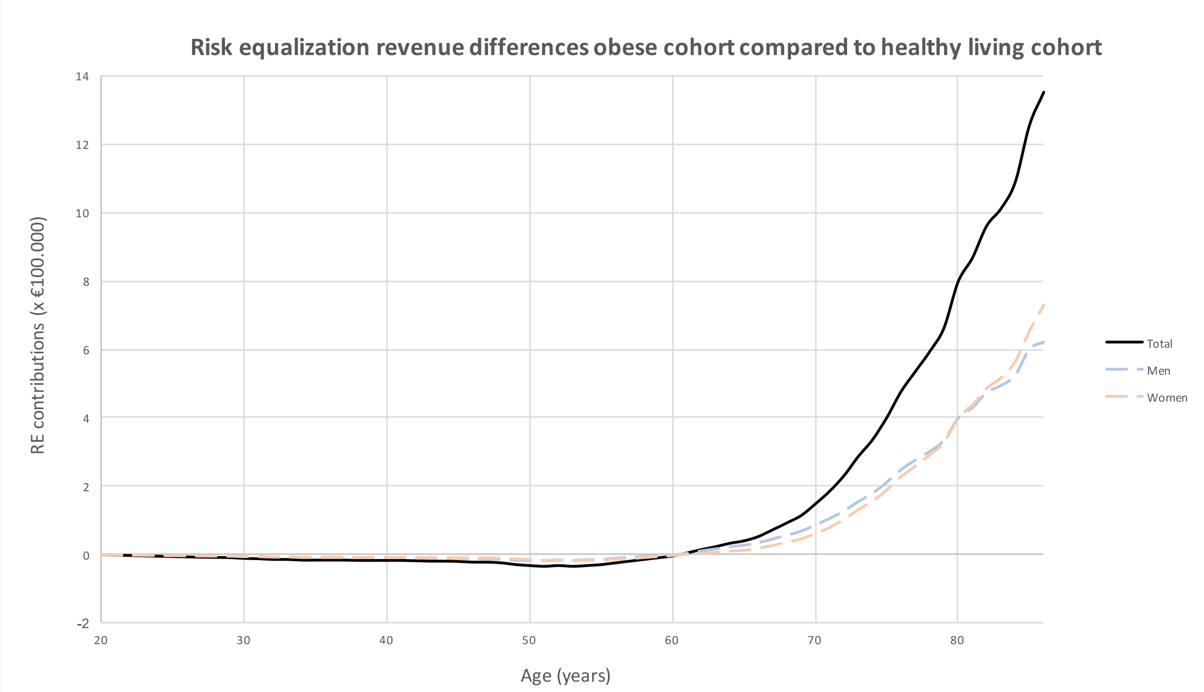


Figure 5: Risk equalization (RE) revenue differences of healthy living cohort compared to the obese cohort over time. Dotted lines depict differences within male and female cohorts. Black line depicts differences for total cohorts (men and women). Negative values depict higher RE contribution for obese individuals comparted to the healthy living and vice versa.

Differences in total risk equalization revenue between the two cohorts are shown in Figure 5. This curve shows a similar pattern as the cost difference curve in the sense that risk equalization revenues are the highest for the obese cohort until the age of 60. Afterwards, the insurer receives more revenues for the healthy living in the long run. However, below the age of 60 difference in risk equalization contributions for the two cohorts is much smaller than the difference in costs (Figure 3). This indicates that the insurer is not able to fully compensate differences in costs between healthy and obese individuals with risk equalization contributions. This imbalance in costs and revenues makes obese individuals financially less attractive for the insurer. At later ages, from the age of 75, this reverses and the obese cohort becomes financially more attractive. Additionally, risk equalization contributions become higher for the healthy living after the age of 60 and costs become higher for the healthy living after 70. This time difference indicates a positive imbalance in costs and revenues in favor of the healthy living, which can be profitable for an insurer and incentivize certain behavior. This pattern is consistent with the net balance (revenues minus costs) for the obese and healthy living cohort, shown in Figure 6.

Till around the age of 40, net balance was negative for both cohorts, meaning that costs exceed revenues. This inverts at age 45 where net revenues become positive. This positive balance seems to peak at the age class 55-59. After age 70, net revenue becomes negative for each cohort again. These positive and negative imbalances for both cohorts make middle age individuals (45-65) extremely financially attractive for insurers regardless of their lifestyle. Young individuals are structurally but moderately undercompensated. In contrast to individuals at old ages, where costs exceed revenues considerably. This makes this last age group financially unattractive.

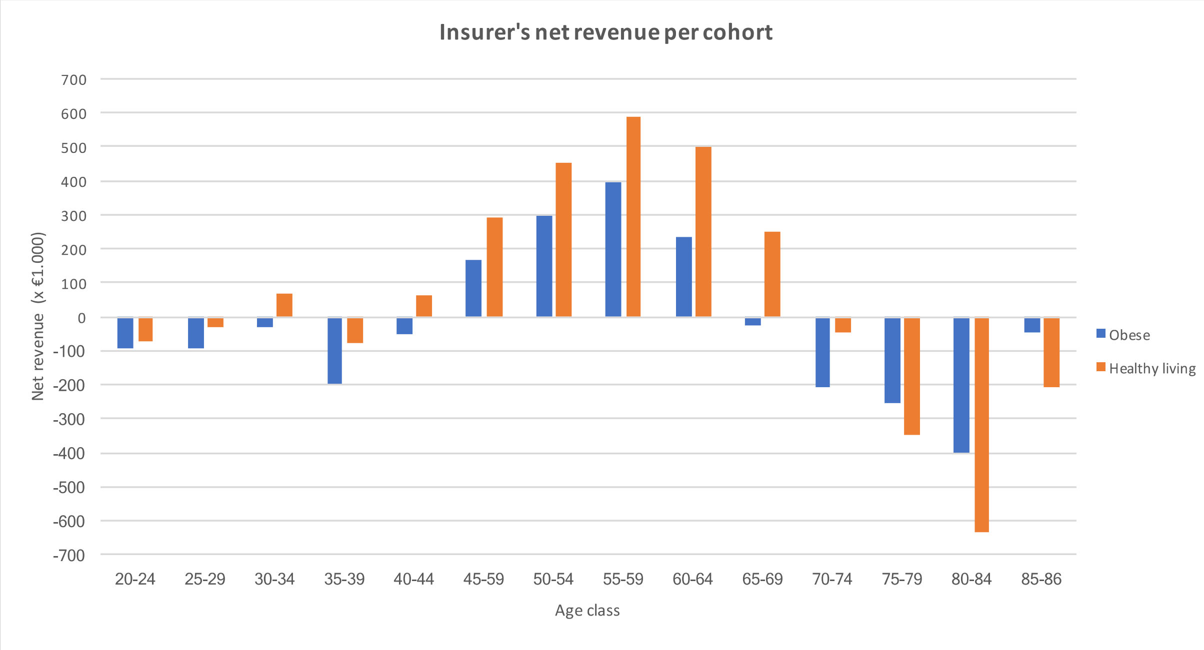


Figure 6: Net revenue (RE contribution minus health care costs) for the insurer per cohort and age class.

Besides different net revenues for different stages of life, differences also occur between the two cohorts. Until the age of 75, the healthy living cohort has the most profitable balance for each age class; making healthy individuals financially attractive over unhealthy individuals. This is most apparent at middle-ages. An insurer could lose up to €300 per year on average on an obese individual compared to an unhealthy individual of the same age. At higher ages, net revenue becomes less negative for the obese cohort compared to the healthy living cohort, making obese individuals more financially attractive for insurers. This difference is mainly caused by the high prevalence of non-obese related diseases and high life expectancy for healthy individuals. The net revenue per person for obese and healthy individuals can be found in the Appendix (Graph B5). Net revenue per individual follows the same pattern as for the whole cohort, but shows a smaller difference between obese and healthy living at the end of life due to the absence of life expectancy.

As mentioned before, total health care costs and risk equalization revenue are highest for the healthy living cohort. Nevertheless, costs and revenues per person are highest for obese individuals over the entire lifetime and per year (on average). Removing the effect of life expectancy, i.e. the relative high number of healthy living individuals at the end of life compared to obese individuals, impacts the cohort's total costs and revenues. However, net revenue (risk equalization revenue minus costs) remains highest on average for the healthy living individual and cohort over the entire lifetime and per year.

Lifetime and yearly costs, revenues and net balances per person are shown in Table 2. Over the entire lifetime of the cohorts, an obese individual incurs most risk equalization revenues and health care costs. Additionally, an obese individual also has the highest costs and revenues per year on average. Despite having higher costs and revenues, the healthy living remained financially more attractive. Net balance per lifetime is negative for both healthy and obese individuals, indicating that an insurer would incur a loss regardless the lifestyle of the individual. Life time risk equalization contributions for all 2000 people in the simulation are 0,5% higher than the corresponding health care costs. As the risk

		LE (at age 20)	Per person RE contribution	Per person health care costs	Per person net balance
Lifetime	Healthy living	64,0	€ 216.901	€ 218.340	-€1.439
	Obese	59,1	€ 236.858	€ 242.874	-€6.016
Per year	Healthy living		€3.237	€ 3.259	-€22
	Obese		€ 3.535	€ 3.625	-€90

Table 2: LE and lifetime or yearly RE contribution, health care costs and net revenues per person for healthy and obese individuals. Net balance is RE contribution minus health care costs.

equalization model is a zero-sum model where negative and positive contributions of different groups should cancel each other out, the negative net balance for both life styles is most likely caused by the prediction error of the 2018 risk equalization model on epidemiological data from 2004.

The losses between the life styles differ substantially in size. An insurer would lose on average €1.439 for a healthy individual, which is €4577 less than for an obese individual. This makes a healthy living individual financially more attractive than an obese individual. Moreover, the yearly net revenue for the healthy living is also most favorable for an insurer. An insurer would lose on average €22 for a healthy living individual and €90 for an obese individual. This difference of €68 is rather small, but do make obese individuals financially less attractive. This could provide insurer's some incentive to engage in prevention (or risk selection). These interpretations are all made on the assumption that individuals join the cohort at age of 20 and remain insured until deceased or arriving at age 86.

In contrast to the results in Table 2, Kanters et al.(2013) shows higher lifetime costs and risk equalization revenues per person for the healthy living compared to obese individuals. This discrepancy is most likely a result of the fact that Kanters et al. was able to simulate costs and revenues over a longer time horizon (entire lifetime of the cohorts), instead till the age of 86. Additional years lived would add additional health care costs and RE contributions to lifetime costs and revenues. Although, lifetime costs and revenues are higher in Kanters et al., the lifetime and yearly difference between the two cohorts can still be used to compare possible prevention or risk selecting incentives of the 2008 model against the 2018 model. The decrease in the gap between obese and healthy living individuals in both lifetime and yearly net revenues, around €250 and €15 respectively, shows that the 2018 model increased in performance. This reduction in net revenue differences shows that the model is better able to identify the risk profile of insureds and match more appropriate risk equalization contributions. However, these findings should be considered with caution as these reductions are still quite modest.

4.3 Effectiveness in obesity prevention and insurer's net revenue

To measure the effect of different levels of prevention efforts on insurer's net revenue, RIVM-CDM computed prevalence rates related to obese are altered with hypothetical prevention health outcomes within the obese cohort at age 20. Subsequently, net revenue (risk equalization revenue minus health care costs) is determined for each health outcome. No concurrence exists about the health outcomes of bariatric surgery. As almost all diseases are potentially reduced by 50% (under optimal conditions) or less after surgery, 50% is used as the starting point for the hypothetical effect of bariatric surgery.

Subsequently, a 5%, 10% and 25% reduction in the prevalence rates of obese related diseases will be used to simulate hypothetical obesity prevention effects.

Figure 7 shows these different levels of prevention health outcomes, i.e. percentage reductions in disease prevalence rates related to obese and how it affects the net revenue per insured (survivor) in the obese cohort. The orange dots represent the insurer's net revenue under a 50% reduction in obese related diseases and show an upward trend over time. This suggests that prevention efforts progressively pay-off as age increases. The dark blue dots present the net revenue in absence of any prevention and are, therefore, identical to the blue bars in Figure 6 for the obese cohort.

From age 20 to 60, different levels of prevention minimally impact insurer's net revenue. At older ages (from age 65), effectiveness of prevention counterbalances the under compensation related to old ages and obesity and positively impacts net revenue. The space between the dots becomes wider, which implicates an increasing effect of prevention on net revenue. Reductions in disease prevalence rates are associated with lower health care costs and risk equalization contributions, but risk equalization revenues don't fall at the same pace as the associated health care costs for the reason that not all prevalent cases ended up in a PCG or DCG classification in the first place. As diseases are most prevalent at older ages, it is expected that prevention will mainly pay-off during high ages of insureds. Reducing obese related diseases and, thus, engaging in prevention could reduce under compensation and make obese individuals financially more attractive.

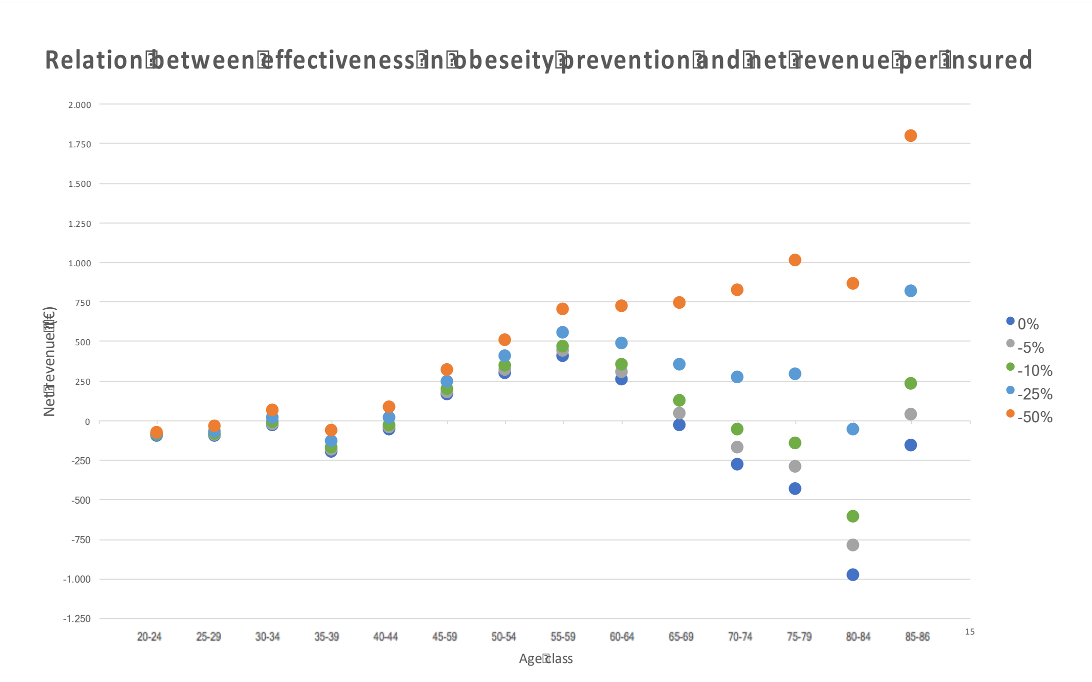


Figure 7: Net revenue (RE contribution minus health care costs) for the insurer per insured and age class for different levels of obesity prevention health outcomes. Percentages indicate the reduction in obesity related disease prevalence rates.

	Reduction in obese related diseases	Per person RE contribution	Per person health care costs	Per person net balance	Per person net balance healthy living cohort
	-50%	€ 230.223	€ 198.490	€ 31.732	
	-25%	€ 233.540	€ 220.682	€ 12.858	
Lifetime	-10%	€ 235.531	€ 233.997	€ 1.534	
	-5%	€ 236.194	€ 238.435	-€ 2.241	
	0%	€ 236.858	€ 242.874	-€ 6.016	-€1.439
	-50%	€ 3.436	€ 2.963	€ 474	
	-25%	€ 3.486	€ 3.294	€ 192	
Per year	-10%	€ 3.515	€ 3.492	€ 23	
	-5%	€ 3.525	€ 3.559	-€ 33	
	0%	€ 3.535	€ 3.625	-€ 90	-€22

Table 3: Lifetime and yearly RE contribution, health care costs and net revenues per person for obese individuals with different levels of prevention health outcomes (in %). Net balance is RE contribution minus health care costs.

Due to the absence of mortality effects caused by the prevention, no reliable inferences can be made about prevention for the total obese cohort. The number of survivors will most likely increase as effectiveness of prevention increases, but this effect is not captured in the calculation of net revenues. However, outcomes concerning lifetime and yearly net revenues per individual can be analyzed. Risk equalization contributions, health care costs and net balances for each prevention level are shown in Table 3. As expected, increases in effectiveness of prevention reduces RE revenues and health care costs. Furthermore, insurer's net balance also becomes more attractive as prevention levels increase. Lifetime and yearly net revenues are still negative under a 5% reduction in disease prevalence rates, but become positive under a 10% reduction of obese related diseases. Implicating that the insurer could make a profit on obese individuals after engaging in prevention. This financial attractiveness increases as the effectiveness of prevention increases. Insurers could gain €474 per year for an obese individual after a 50% reduction of obese related diseases under the (unrealistic) assumption that prevention would not increase life expectancy.

It appears that prevention pays off for an insurer in terms of increased net revenue. However, in order to exploit these benefits, insurers first have to invest in prevention. Bariatric surgery and after care costs approximately sum up to €9.700. These costs could potentially increase, for example after surgery complications. Taking into account this initial investment reduces the financial attractiveness of prevention. From the lifetime perspective, a 10% reduction in obese related diseases cannot make up for the costs related to the prevention investment (in this case bariatric surgery) and is not financially attractive anymore for the insurer. Furthermore, net revenues per year indicate that insurers would need several years to gain back the investment costs. In the favorable case of a 50% reduction in obese related diseases, insurers would still need more than 20 years before the prevention investment is fully redeemed. Discount rates are not taken into account here. If we use a discount rate of 4%, pay-back period of prevention investment would more than double and be about 48 years.

Chapter 5. Conclusion

This section describes the conclusions that can be drawn from the empirical results in this paper and it discusses the relevance, limitations and potential threats of this study with recommendations for further research.

5.1 Conclusion

This paper has quantified the financial attractiveness of obese and healthy living individuals under the 2018 Dutch Risk Equalization Model. This research shows that unpriced risk heterogeneity exists for the two cohorts. The healthy living individuals incurred the highest aggregated health care costs and revenues over their entire lifetime. This was mainly a consequence of the higher life expectancy and high prevalence of non-obese related diseases at high ages. Obese individuals, on the other hand, incurred most costs and risk equalization revenues per person over their lifetime and per year. Different financial incentives exist between young, middle-age and older individuals. In general, middle age individuals are substantially overcompensated, where individuals at higher ages are significantly undercompensated. Additionally, financial incentives exist between the healthy and obese cohort. Healthy insureds had the most profitable balance of the two (least negative), per year and for their total lifetime. This indicates that insurers face financial incentives to engage in health improving activities or risk selecting. However, healthy insureds were more undercompensated at high ages than obese individuals. This indicates that prolonged life due to prevention could have decreased corresponding prevention incentives. The net revenue differences over the cohorts' lifetime (€4500) and per year (€70) are quite modest, indicating that the financial incentives for insurers are also quite limited.

Comparison of the empirical results found in this study with findings from Kanters et al. (2013) shows that improvement in the risk equalization model reduces financial imbalances between healthy living and obese individuals over their lifetime (€250) and per year (€15). Increased prediction of the model decreases the financial incentive for insurers to engage in health promoting activities, but also the incentive to engage in risk selection. This trade-off shows that the prevention paradox exists and should be taken into account during further improvements of the risk equalization scheme.

Furthermore, in this research different levels of prevention are examined in relation to risk equalization revenues and health care costs. The more effective the prevention treatment, expressed in reductions of obese related diseases, the more profitable and financially attractive an obese individual became (without taking into account prolonged life due to prevention). This effect was most profound at older ages due to the normally high prevalence of diseases around that age. Health care costs would fall more than risk equalization contributions, since not all prevalent cases were classified in a PCG or DCG classification in the first place. By increasing the effectiveness of prevention, insurers are able to off-set under compensation obese individuals experience at older ages. This decreases the financial unattractiveness of obese individuals and, simultaneously, decreases the financial difference between healthy and obese individuals which also weakens risk selecting incentives. The pay-back period of the bariatric surgery as prevention method is more than 20 years under the most favorable conditions of a 50% reduction in obese related diseases and even 48 years using a discount rate of 4%. This implies that insurers, even under optimal circumstances and not taking into account other uncertainties, are most likely discouraged to invest in prevention without any other (financial) incentives.

5.2 Discussion

The prevention paradox is researched in this paper by comparing the empirical results found in this study with findings from Kanters et al. (2013). Comparison shows that improvement in the risk equalization model reduces financial imbalances between healthy living and obese individuals. Increased prediction of the model decreases the financial incentive for insurers to engage in health promoting activities, but also the incentive to engage in risk selection. The main goal of risk equalization is to create a fair level playing field for insurers, reduce incentives for risk selecting and stimulate careful purchasing of health care. Stimulating health promotion and investing in prevention could qualify as careful purchasing of health care, as insurers are engaged in efficient purchasing of care by reducing unnecessary use of health care resources in the future. Reducing risk selection incentives by including obese related risk factor classes in the model, potentially trade-offs incentives for efficient purchasing of care. Insurers are in that case better compensated for obese related costs and feel less need to invest in prevention of chronic diseases. As insurers are expected to act as careful purchaser of care and, thus, engage in preventative actions, this contradictive mechanism is not socially desirable.

Additionally, different levels of prevention are tested in relation to insurer's net revenue. Results show that increased effectiveness of prevention, increases the financial attractiveness of obese individuals and, therefore, reduces the financial difference between the life styles of insureds. However, as the investment in obesity prevention (in this paper bariatric surgery) takes a long time to earn back and taking into account other uncertainties that could influence prevention outcomes, investing in risk selection might be more effective and cheaper for an insurer. Under favorable circumstances (50% reduction in obese related diseases) it still takes an insurer more than 20 years to win back the initial investment. This win-back period is more than twice as long when taking into account a discount rate of 4% for future health care costs and risk equalization revenues. Possible higher costs and a longer return time due to additional hospital costs, poor reliability of treatment outcomes and individual circumstances are also not included in the initial investment here. Furthermore, the risk exists of insureds switching insurer after receiving the bariatric surgery (or another prevention initiative). The insurer is then left with a failed investment and the benefits of the prevention are consumed by the competitor. Hence, although effective prevention increases the profitability of obese individuals (or make the financial loss less negative) due to the long-time horizon to recover initial prevention costs and other uncertainties such as insureds switching, insurers might be incentivized into (relative cheaper) risk selection. Risk selecting can be more effective and cheaper as effects are noticeable in the short term and can be targeted at low or high risk individuals at the group level. This stresses the need for the incorporation of additional (financial) prevention incentives and reducing the existing selection incentives in the model.

As the aim is to continuously improve the prediction of the risk equalization model to reduce risk selecting incentives, policy makers face an incentive trade-off with reduced incentives for health promotion. The financial pressure on the health care system and the movement from sickness and care to health and behavior asks for more attention towards prevention of chronic diseases. If insurers are expected to have a prominent role in stimulating prevention of chronic diseases and healthy life styles, an optimal balance of incentives is a prerequisite. The current risk equalization model does not produce optimal incentives for both discouraging risk selecting and health improving behavior. Improvement of the risk equalization model is socially desirable to minimize risk selecting incentives. As improvements of the risk equalization model reduce the financial differences between health styles of insureds, policy makers face the task to implement additional financial stimulus for prevention. Just including obese related risk classes in the risk equalization model will further reduce risk selecting incentives between healthy living and obese insureds, but also the possibility to benefit from the previously existing unpriced risk heterogeneity. Hence, additional incentives outside the model are needed to stimulate insurers to engage in prevention.

Combining risk equalization contributions with pay-for-prevention is an example (Eggleston et al., 2012). Insurers are rewarded with incremental payments if the progression of diseases in their insured pool is better than expected or penalized when worsened. This payment depends on the ability of the insurer to influence health outcomes and the quality of results. These additional pay-for-prevention contributions can be used in a separate prevention equalization model. Implicating that insurers who do not engage in prevention or fail to deliver the desired health outcomes, need to pay for the succeeding prevention efforts of competitors and vice versa. This financially incentivizes insurers to at least produce the same prevention efforts as their competitors. Furthermore, it stimulates efficient purchasing of care and good disease management. Insurers excelling in prevention could potentially use these advantages to select high-risk profiles on the premise of receiving prevention bonuses.

As mentioned before, improvement of the current risk equalization model will further decrease risk selecting incentives and, simultaneously, decrease the net revenue differences between different life styles of insureds. Bariatric surgery as prevention initiative is not financially attractive for an insurer under the current model with optimal conditions due to the long win-back period of the initial costs and the risk of insurers switching afterwards. Furthermore, as prevention of obesity reduces obese related diseases, it is highly likely that these diseases are substituted by other diseases at a later point in time. This implicates that the health care costs reduced by prevention are substituted by other health care costs, which makes the investment even less financially attractive. The prevention effect in this paper is most likely overestimated as substitution of diseases is not taken into account. Additionally, the effect of prevention on mortality is not taken into account in this paper. As prevention, will most likely increase life expectancy and subsequently health care costs and risk equalization contributions, this will impact the net revenue for insurers. The direction in which net revenue is impacted is unclear, as this depends both on the substitution of obese related diseases with other diseases and the effectiveness of the prevention method. As elderly are undercompensated by the risk equalization model and many uncertain factors influence prevention health outcomes, it might negatively affect insurer’s net revenue for prevention. This emphasizes again that other (financial) incentives for prevention are needed outside the risk equalization model to encourage prevention efforts by insurers. Implementing prevention subsidies could provide insurers an incentive to engage in prevention. Each insurer will receive the same prevention budget and is stimulated to spend it as efficiently as possible. Establishing a prevention fund is another example of a financial stimulus. Insurers reaching pre-determined prevention targets receive a payment from the fund. Furthermore, other non-financial incentives could be used to stimulate health-improving initiatives by insurers. For example, assessing and publishing the ranking of insurers based on their prevention efforts provides a reputation incentive. Furthermore, increasing the stay period of insureds after receiving prevention could counteract the fear for failed prevention investments for insurers. These suggestions are not exhaustive and combining them will add more value as more relevant aspects are targeted than used individually.

Lastly, the question arises who should bear the financial costs of unhealthy behavior. If we look at Dutch health insurance system with open enrollment, community rated premiums and imperfect, or rather not perfect, risk equalization, this financial risk falls largely on insurers. Insurers are unable to translate the increased financial risk of unhealthy behavior to their insureds. The obligatory deductible of €385 shifts the financial risk partly to the insured, but only to a small extent as obese related health care costs will most likely surpass this threshold. In the case of perfect risk equalization and community rated premiums, the financial risk is shared collectively. However, the results of this study show that risk equalization is indeed not perfect and the financial risk of unhealthy behavior falls directly on the insurer. Insureds will face the consequences of unhealthy behavior indirectly and collectively in the long run as the costs of unhealthy behavior are translated into higher premiums for all insureds. The desired distribution of financial risks related to unhealthy behavior seems an economic welfare but also political choice. To share the financial risk of unhealthy behavior with insureds, allowing risk-adjusted premiums to a certain extent could be a solution. Vice versa, healthy insureds could be rewarded with lower premiums if certain health care costs thresholds are not met. These suggestions go against the solidarity principles of the Dutch health care system and simultaneously implicates a societal trade-off between solidarity and bearing financial responsibility for unhealthy behavior. Not giving in on equity and access to care then implies perfect risk equalization to shift the risk of unhealthy behavior from the insurer to the insured.

Some limitations in this study are important to highlight here. As the RIVM-CDM output only consisted of aggregated disease prevalence rates and lacked further (individual) insured data, e.g. socio-economic or demographic information, only three of the 12 parameters of the 2018 risk equalization model could be explicitly used. Other non-direct health parameters (SES, region, SoI) or direct health parameters (sDCG, PHCG, MHC) most likely further explain differences between obese and healthy living and, therefore, decrease the financial difference between the two cohorts for insurers. For example, numerous articles have written about the negative association of obesity and SES, especially for women in high income countries (McLaren, 2007; Monteiro et al., 2005; Newton et al., 2017). This indicates that the financial difference between the two cohorts under the 2018 risk equalization model is most likely overestimated in this paper, since multiple considerable variables are not explicitly taken into account.

Furthermore, using RIVM-CDM input data from 2004 in combination with the risk equalization model from 2018 will most likely cause some prediction error in estimating the risk equalization contributions for the cohorts. The risk equalization model of 2018 is in principle a zero-sum model based on recent health care costs, epidemiological and geographic trends. This implicates that the contribution values of the risk classes of each parameter are determined on the basis of these epidemiological and geographic data from 2018 or some years before. Hence, this mismatch in data influences the accuracy of the computed risk equalization contributions for each cohort and could potentially differ when the RIVM-CDM was used with input data from 2018. Additionally, a constant ratio of pDCG's to disease prevalence is used to determine the number of ill individuals who actually end up with a pDCG classification under the risk equalization model. Due to age and gender risk adjusters in the risk equalization model, this ratio is used for all ages and gender. In reality, it is likely that not all variation in pDCG classifications is explained by these age and gender risk adjusters. It can be assumed that the pDCG to disease prevalence ratio is higher at older ages as these age group tends to receive more medical care due to more severe illnesses. The number of pDCG classifications is, therefore, likely to be underestimated at older ages. Furthermore, the assumption was made that the pDCG to disease prevalence ratio, mainly intramural care, could be used for the PCG classifications related to the corresponding disease, mainly extramural care. This assumption will most likely not hold in practice as extramural care is a different type of care. For example, a diabetes patient will most likely have an insulin pen prescribed for daily injections. This pharmaceutical use is constant over the year and will most likely not change quickly. Hospitalization of a diabetes patient is far less frequent and predictable. Hence, the PCG classifications of obese related diseases is most likely overestimated. Lastly, the sDCG is not explicitly used in this research due to the shortcoming of the RIVM-CDM to simulate co-morbidity of diseases. The sDCG functions as an extra parameter to better predict health care costs of insureds with co-morbidities. Obese individuals are known for having multiple co-morbidities (Daphne P et al., 2009). The explicit use of sDCG in this paper could have increased the prediction of health care costs with risk equalization contributions and decreased financial differences between healthy living and obese individuals. This implicates that the net revenue differences of the cohorts might be overestimated.

Lastly, the risk equalization model for somatic care is used in this research, excluding long-term and mental health care. The results show that healthy insureds were solely more undercompensated at high ages (from the age of 75) than obese individuals. The high prevalence of non-obese related diseases and high life expectancies of healthy living were the main contributing factors. It could be the case here that healthy living individuals incur more somatic health care costs under the health insurance act at high ages than obese individuals, because well-educated and married people are on average healthier and live longer at home using health care under the Health Insurance Act (ZVW). Obesity is known as a major risk factor for developing non-communicable chronic diseases, which increases the chance for obese individuals to end up receiving care at home or in a facility under the Long-term Care Act (WLZ). The latter costs of care are not part of the risk equalization model and were, therefore, excluded in the calculation of health care costs. In this case, it is possible that with the inclusion of long term care, obese individuals in our paper actually incurred more health care costs than healthy living people at older ages. The risk equalization model is designed to predict the somatic health care costs of insureds. The substitution of somatic health care costs by long-term care costs for obese individuals could be a possible explanation for the less severe under compensation for obese individuals. The under compensation at older ages for obese individuals could be in practice larger than estimated in our paper. Further research including the model for long-term care costs is needed to prove these suggestions.

5.3 Recommendations for further research

The first recommendation for further research would be to refine this paper by including all risk parameters in the analysis for obese and healthy living individuals. These health or non-health related parameters have different influences on risk equalization contribution differences between healthy and obese individuals. Including all parameters will give a more accurate and precise estimation of the financial incentive to engage in risk selecting or health promotion for the two groups.

Secondly, further research should focus on other ways of financing and stimulating prevention efforts from insurers. This includes researching external prevention incentives in or outside the risk equalization model. As described in the discussion, further (financial) incentives are needed to stimulate insurers to engage in health improving behavior and prevention. As the prevention of chronic diseases itself does not guarantee financial profits for insurers in the future and prevention incentives under the risk equalization model are very limited, policy makers are forced to implement additional stimuli to stimulate prevention. Researching possible additional prevention incentives and the optimal balance between risk selecting and prevention incentives under the risk equalization model is recommended.

Lastly, further research concerning the effects of prevention in general is recommended. More knowledge on different prevention methods and their effects are needed to make inferences about the existence of prevention incentives. Currently, solid and indisputable evidence is lacking about health outcomes and associated (health care) costs. Especially investments in early prevention, such as life style interventions, are uncertain in their outcomes. It does not largely depend on the prevention treatment itself, as with bariatric surgery, but also on individual traits and environments, who's are not easy to change. Little research has been performed on the effects of prevention compared to a situation without prevention. To wat extent and when is prevention actually necessary for an individual and at which stage profitable? Additionally, the question arises to what extent health care costs actually decrease after prevention. In this paper, prevention of obesity is equated to healthy living people. In practice, different degrees of health exist after receiving prevention depending on the method and other (personal) circumstances. This influences associated health care costs and risk equalization contributions and, hence, incentives for risk selecting and prevention. Further research in the field of prevention is needed in order to understand which (financial) incentives insurers need to be stimulated to engage in prevention and other health improving behavior.

APPENDIX

Part A: Simulation input

Table A1: Diseases related to obesity and smoking used in the RIVM-CDM to simulate different health-style cohorts (Source: (van Baal et al., 2006)). Additionally, ICPC and ICD-10 classification codes are shown for each disease.

	Disease	Related to obesity	Related to smoking	ICPC	ICD-10
Cardiovascular disease	Acute myocardial infarct (AMI)	X	X	K75	I21-I22
	Angina pectoris	X	X	K74	I20
	Chronic heart failure	X	X	K77.02	I50
	Stroke (CVA)	X	X	K90	I60-I69
Cancer	Lung		X	R84	C33-C34
	Stomach		X	D74	C16
	Oesophagus		X	D77.01	C15
	Pancreas		X	D76	C25
	Oral cavity		X	D77.03	C00-C06
	Larynx		X	R85	C32
	Urinary bladder		X	U76	C67
	Kidney	X	X	U75	C64
	Rectum	X		D75	C20
	Colon	X		D75	C18-C19
	Breast	X		X76	C50
	Prostate	X		Y77	C61
	Endometrium	X		X77.01	C54
Other	COPD		X	R91	J40-J42
	Diabetes	X	X	T90	E10-E14
	Arthrosis of the hip	X		L90	M16
	Arthrosis of the knee	X		L89	M17
	Dorsophaties (low back pain)	X		L03, L86	M54

Formula A1: In order to calculate the relative risk for other cause mortality for the different obese risk classes, substitution of formula 1 in 2 is needed to calculate the baseline rate for all-cause mortality in the normal weight class (formula 3) (van Baal et al., 2006).

(1) $$RR(oc|b_k) = \frac{RR(tot|b_k) * m(tot)_{0B} - \sum_d RR(d|b_k) * am(d) * p(d)_{0B}}{m(oc)_{0B}}$$

(2) $$m(oc)_{0B} = \frac{m(oc)}{\sum_k RR(oc|b_k) * b_k}$$

$RR(oc|b_k) = relative\ risk\ other\ cause\ mortality\ rate\ for\ obese\ risk\ class\ k$
$RR(tot|b_k) = relative\ risk\ all\ cause\ mortality\ for\ obese\ risk\ class\ k$
$m(tot)_{0B} = baseline\ all\ cause\ mortality\ rate\ for\ normal\ weight\ class$
$p(d)_{0B} = baseline\ prevalence\ rate\ disease\ d\ for\ normal\ weight\ class$
$m(oc)_{0B} = baseline\ other\ cause\ mortality\ rate\ for\ normal\ weight\ class$
$m(oc) = mortality\ rate\ for\ other\ causes\ of\ death$
$b_k = prevalence\ rate\ for\ obese\ class\ k$
$b_0 = prevalence\ rate\ for\ normal\ weigth\ class\ (b = 0)$

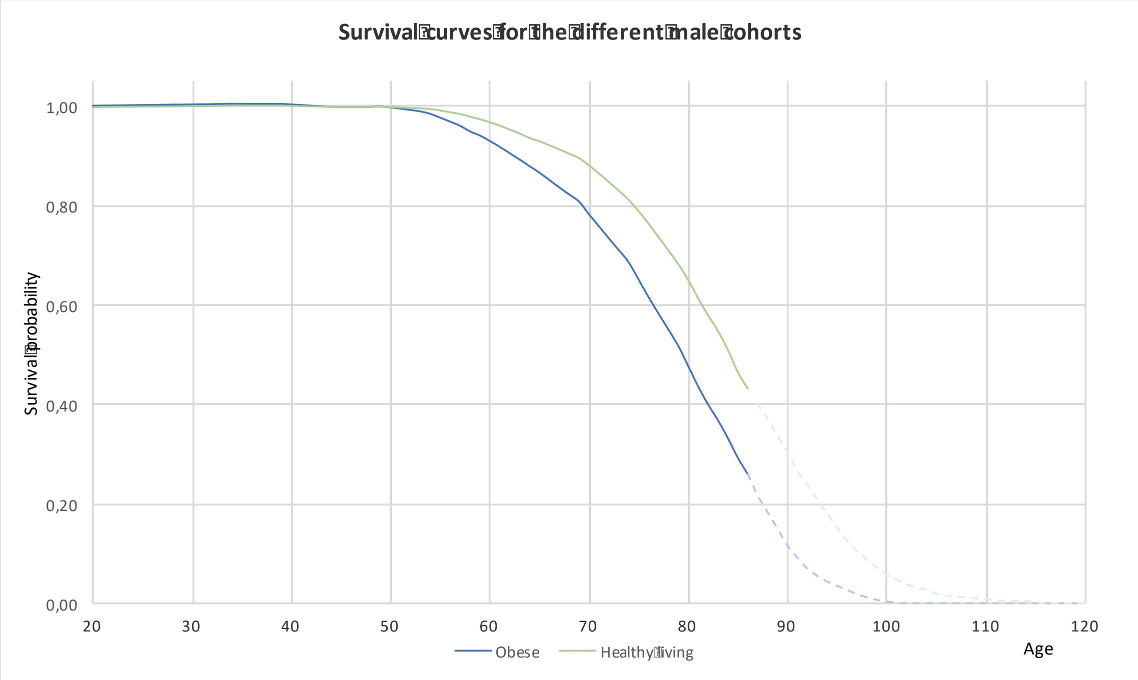
(3) $$m(oc)_{0B} = \frac{m(oc) - \sum_{k=1}^{2}(RR(tot|b_k) * m(tot)_{0K} - \sum_d RR(d|b_k) * am(d) * p(d)_{0B}) * b_k}{b_0}$$

Table A2: DX-group classification with their related pDCG for each modeled disease. Two DX-group classifications indicate two possible ways to classify the disease. The proportion of patients in each DX-group classification per disease is based on ZiNL insureds data from 2018. Additionally, the ratio of related pDCG's per disease to disease prevalence is given in the last column.

Disease	DX-group classification		pDCG classification		Proportion patients		Ratio of pDCG's to disease prevalence (%)
Acute myocardial infarct (AMI)	21081	31081	5	3	0,01	0,99	14,23
Angina pectoris	31084		0		1,00		18,60
Chronic heart failure	31089		2		1,00		37,00
Stroke (CVA)	211093		4		1,00		16,66
Lung	91013	21013	5	11	0,79	0,21	5,92
Stomach	71010	91010	5	5	0,36	0,64	43,81
Oesophagus	71009	91009	8	5	0,69	0,31	36,29
Pancreas	21009		7		1,00		32,35
Oral cavity	231008		7		1,00		18,14
Larynx	21008	232007	10	2	0,21	0,80	45,11
Urinary bladder	21019	107019	10	4	0,10	0,90	76,68
Kidney	21019	102019	10	4	0,26	0,74	53,25
Rectum	71011	97011	6	1	0,65	0,35	31,38
Colon	71011	91011	6	4	0,52	0,48	31,38
Breast	21014	91014	0	0	0,35	0,65	60,79
Prostate	21018	101018	9	2	0,16	0,84	39,76
Endometrium	151016	21016	5	7	0,86	0,14	19,51
COPD	21105	41105	7	4	0,01	0,99	40,33
Diabetes	21027	333025	0	5	0,28	0,72	5,20
Arthrosis of the hip	51050		1		1,00		2,27
Arthrosis of the knee	51050		1		1,00		2,32
Dorsophaties (low back pain)	500036		4		1,00		3,44

Part B: Additional empirical results

Graph B1 and B2: Survival curves for male and female cohorts, each starting with 500 individuals at age 20. Dotted lines are an extrapolation of the predicted survivors based on survival curves from van Baal et al. (2006).



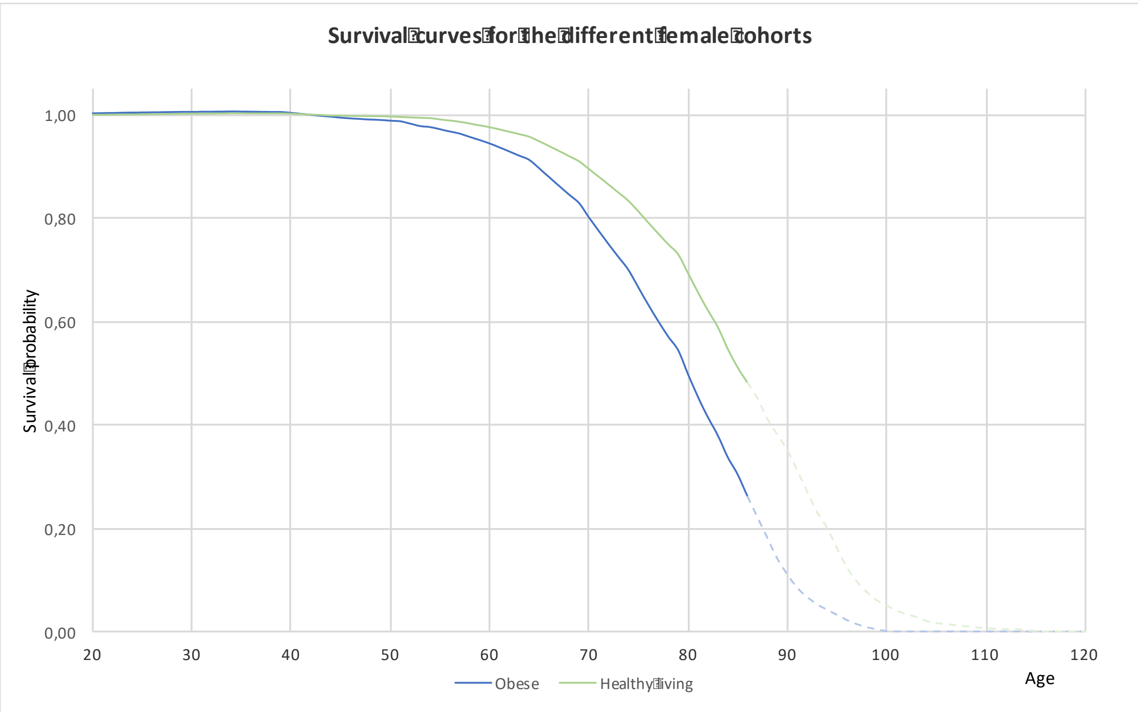
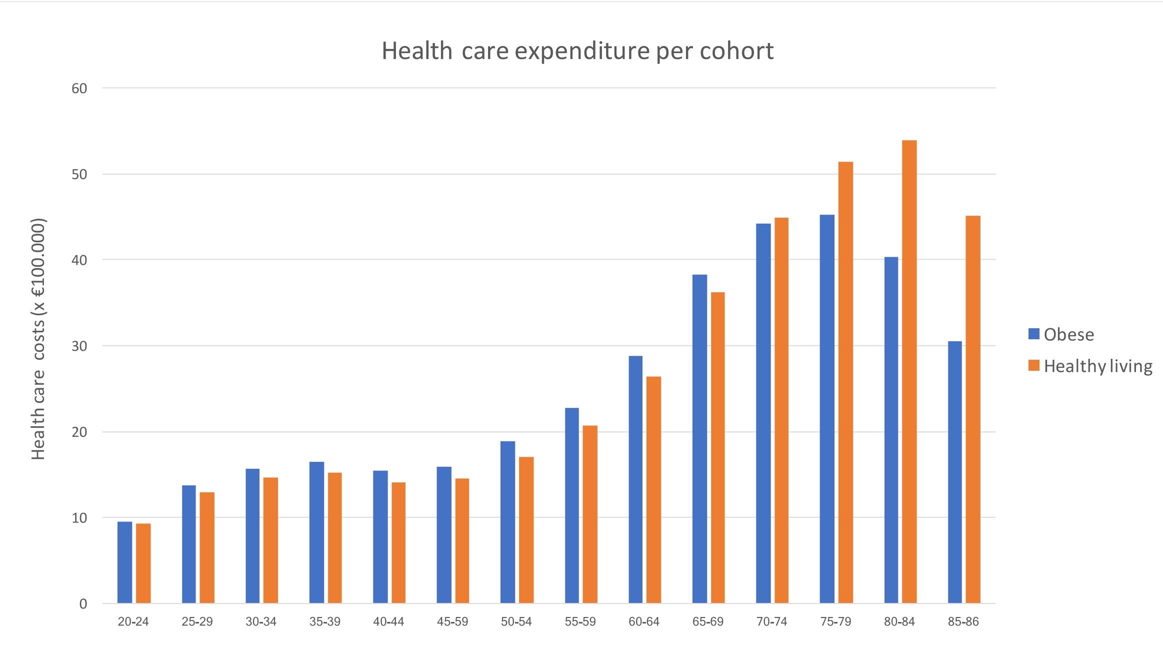


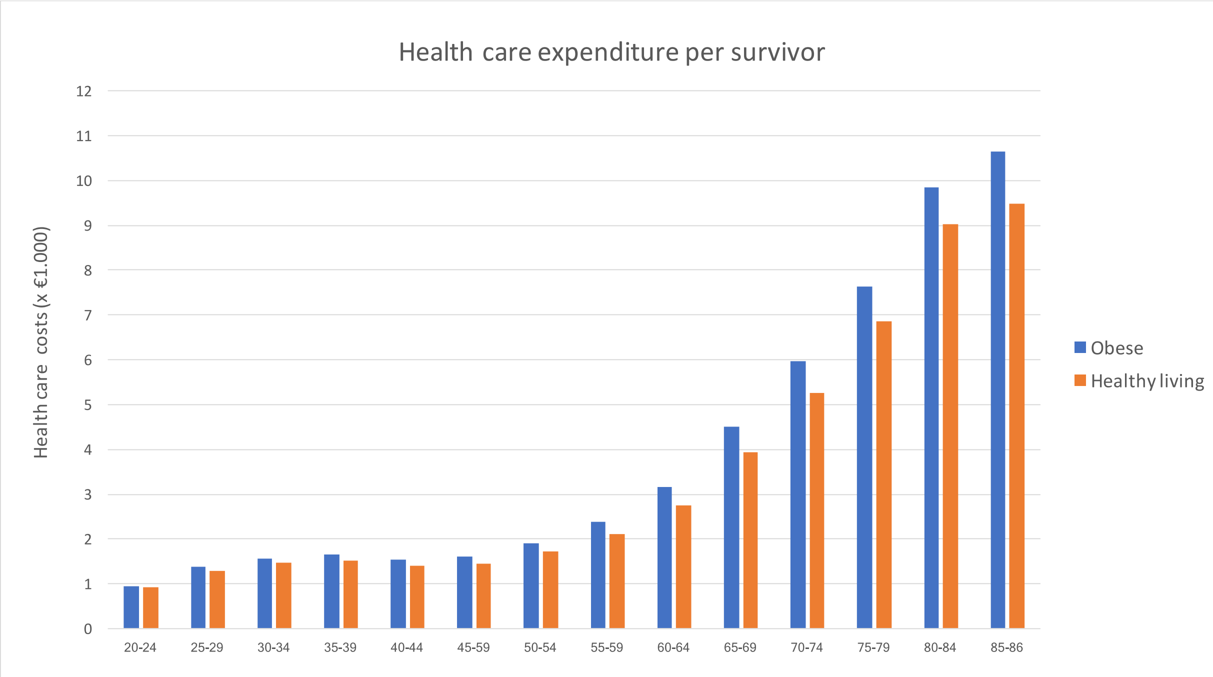
Table B1: Mortality rates at age 86 for each male and female cohort with the expected and difference in life expectancy at age 20 in years. Mortality rates for the total cohorts (men and women) are based on the proportion of male and female survivors at age 86.

Cohort		Cohort specific mortality rate at age 86	LE at age 20	Difference in LE
Men	'Healthy living'	0,1587	63,4	4,6
	Obese	0,1858	58,8	
Women	'Healthy living'	0,1350	64,6	5,2
	Obese	0,1628	59,4	
Total	'Healthy living'	0,1463	64,0	4,9
	Obese	0,1742	59,1	

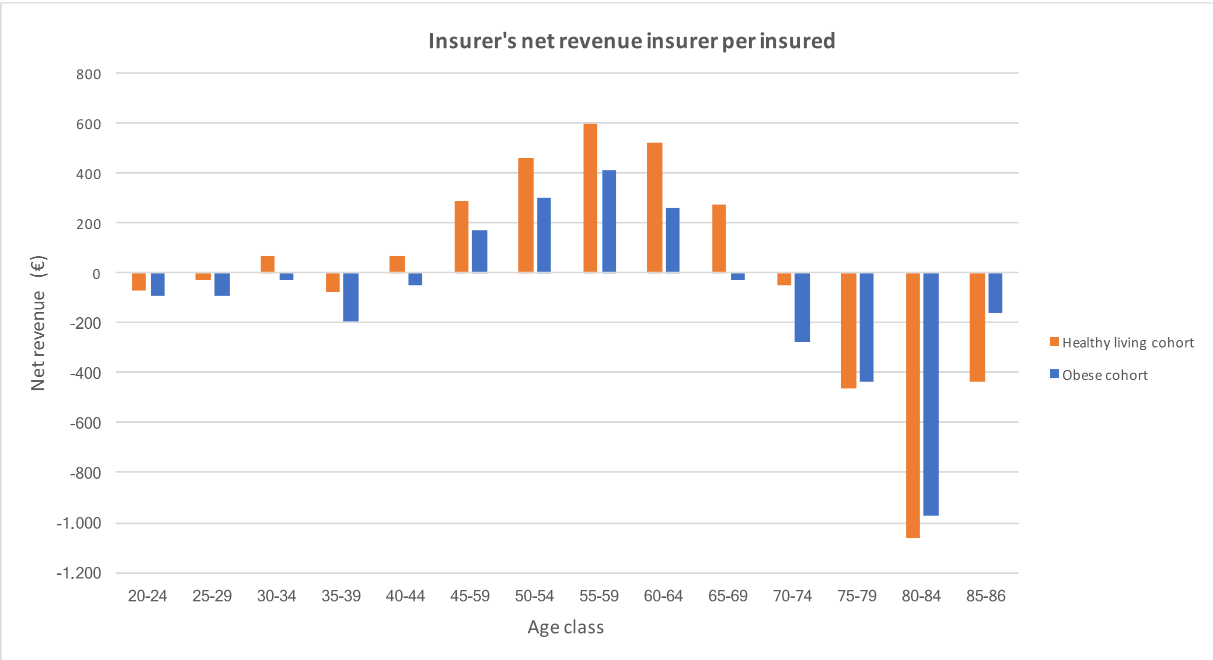
Graph B3: Aggregate health care expenditure for the healthy living and obese cohort per age class. Health care expenditure is expressed in €100.000.



Graph B4: Health care expenditure for an obese or healthy living individual per age class. Aggregate health care expenditure is divided by the number of survivors in the corresponding cohort. Health care expenditure is expressed in €1.000.



Graph B5: Net revenue for an obese and healthy living individual per age class. For each age class aggregate health care expenditure is subtracted from total risk equalization contribution and divided by the number of survivors in the corresponding cohort to achieve net revenues per insured.



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